US009236832B2

(12) **United States Patent**
Sherman et al.

(10) **Patent No.: US 9,236,832 B2**
(45) **Date of Patent: Jan. 12, 2016**

(54) **INTERCONNECTING STRIPS FOR BUILDING INTEGRABLE PHOTOVOLTAIC MODULES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 936 days.

(21) Appl. No.: **13/277,509**

(22) Filed: **Oct. 20, 2011**

(65) **Prior Publication Data**

US 2013/0098420 A1 Apr. 25, 2013

(51) **Int. Cl.**

H01R 11/00 (2006.01)
H02S 40/34 (2014.01)
H02S 20/23 (2014.01)
H01R 13/187 (2006.01)
H01R 13/52 (2006.01)

(52) **U.S. Cl.**

CPC ***H02S 40/34*** (2014.12); ***H02S 20/23*** (2014.12); *H01R 13/187* (2013.01); *H01R 13/5219* (2013.01); *Y02B 10/12* (2013.01); *Y10T 29/49355* (2015.01)

(58) **Field of Classification Search**

CPC H02S 40/34; H02S 20/23; H01R 13/187; H01R 13/5219; Y10T 29/49355; Y02B 10/12

USPC 439/500, 502, 627, 660, 709, 875, 883; 136/244, 245, 256

See application file for complete search history.

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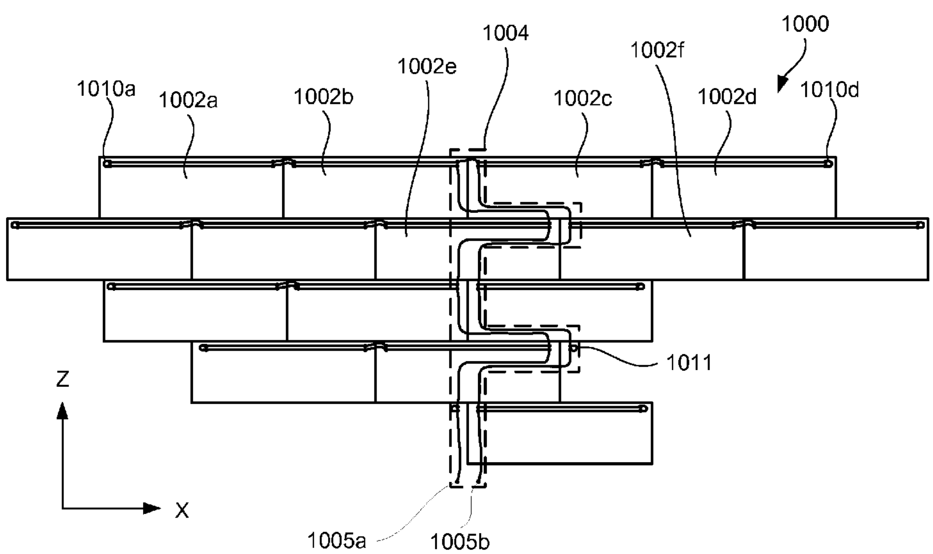
(74) *Attorney, Agent, or Firm* — Weaver Austin Villeneuve & Sampson LLP

(57) **ABSTRACT**

Provided are novel interconnecting strips for electrically connecting building integrable photovoltaic (BIPV) modules in a photovoltaic array. An interconnecting strip can be provided between a building structure and the BIPV modules, with electrical connections established by lowering the modules onto the strip previously positioned on the structure. The strip can includes two or more terminal groups aligned with different rows of BIPV modules. Each terminal group includes two or more connector terminals for connecting to the modules in that row. The interconnecting strip also includes leads extending between terminal groups and connecting connector terminals of different groups. In certain embodiments, terminal groups are offset with respect to adjacent groups to align with BIPV modules that are similarly offset to provide a moisture barrier. The interconnecting strip may be reconfigured in the field to provide different electrical connection schemes among BIPV modules.

10 Claims, 17 Drawing Sheets



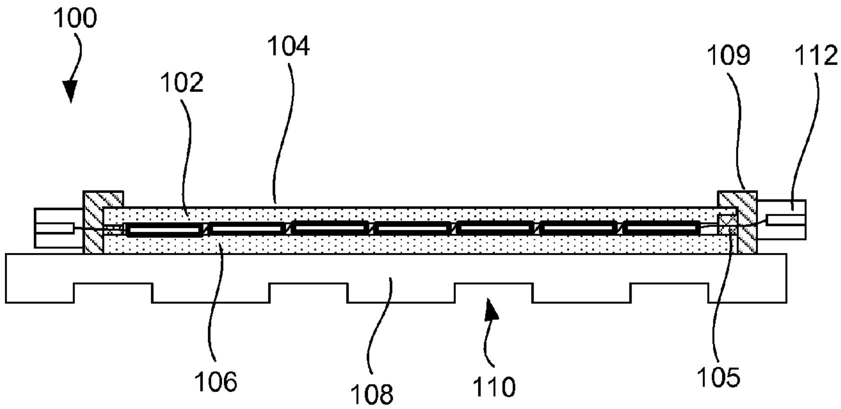

100
102
104
109
112
106
108
110
105

FIG. 1

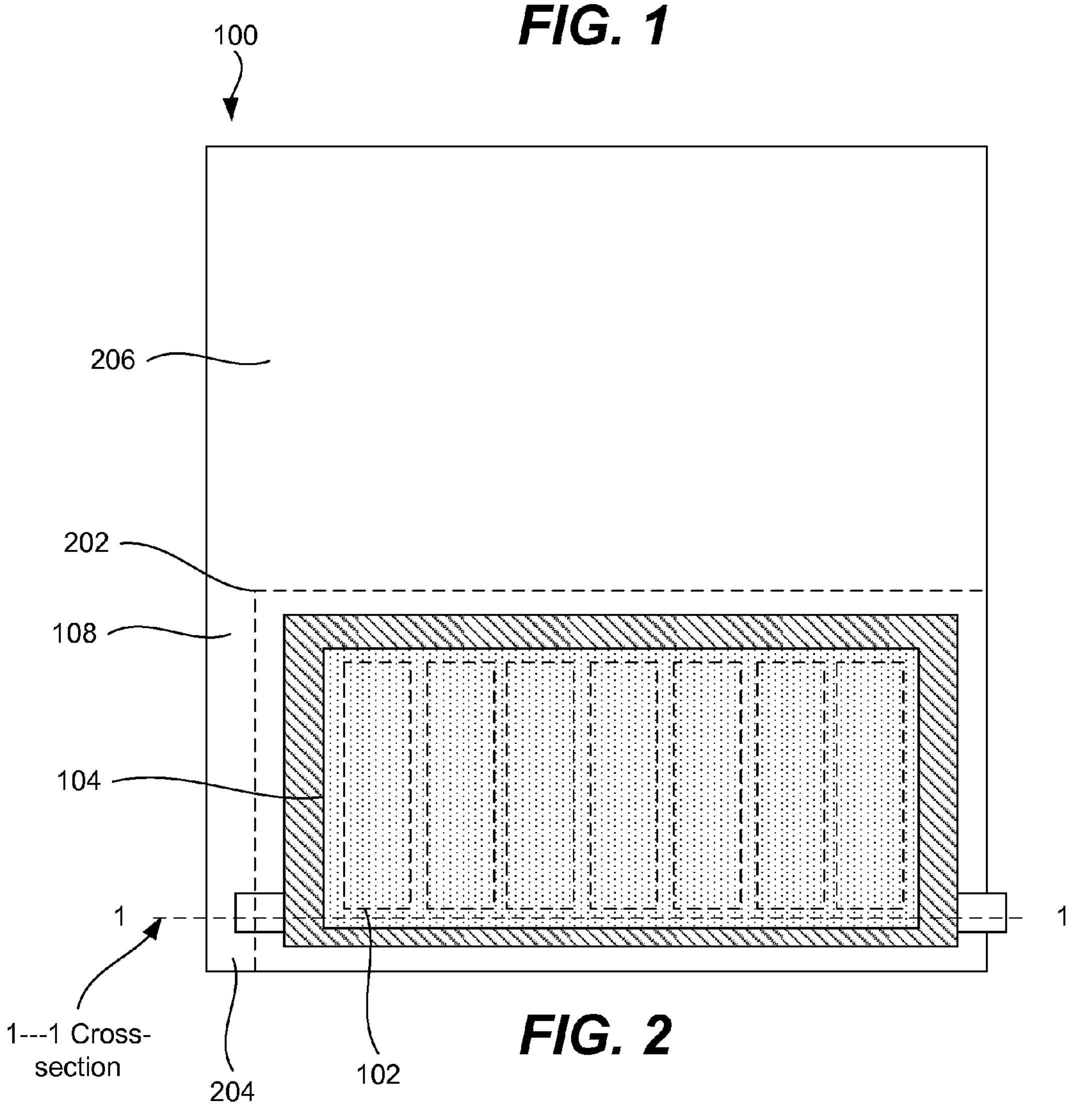

100
206
202
108
104
1
1
1---1 Cross-section
204
102

FIG. 2

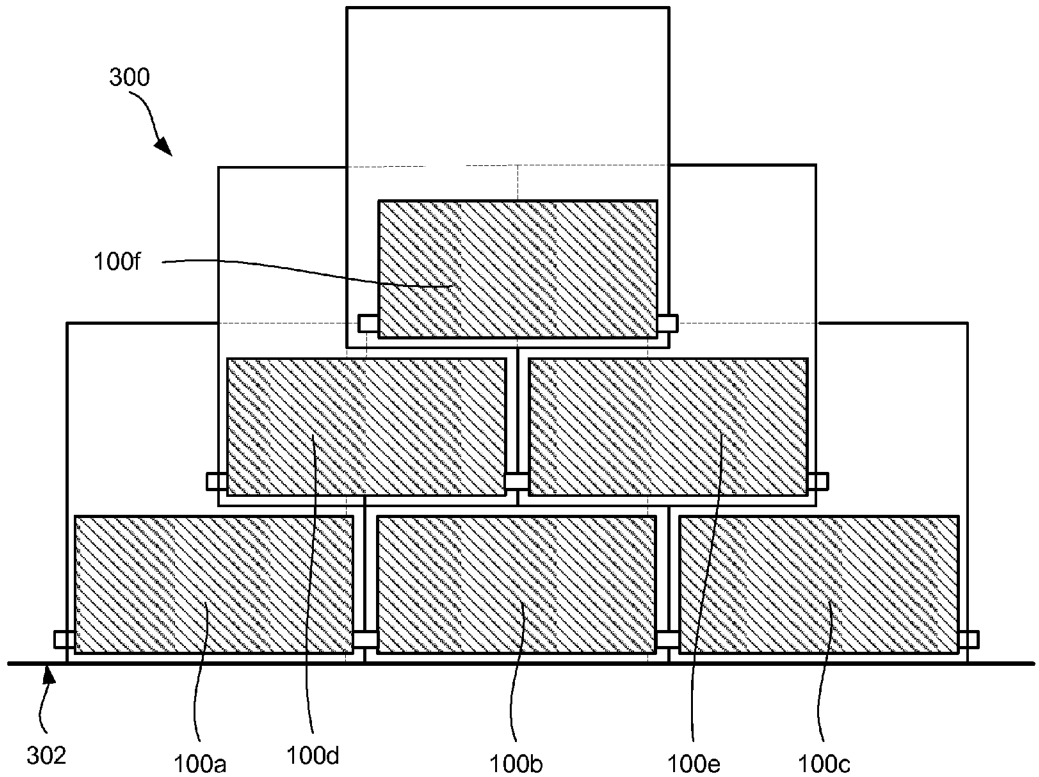

300
100f
302
100a
100d
100b
100e
100c

FIG. 3

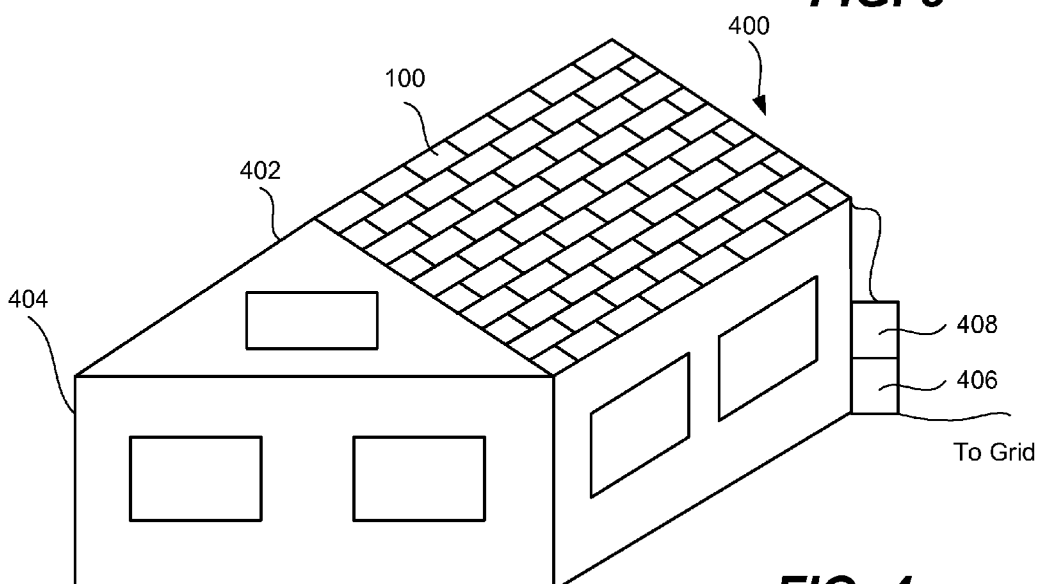

400
100
402
404
408
406
To Grid

FIG. 4

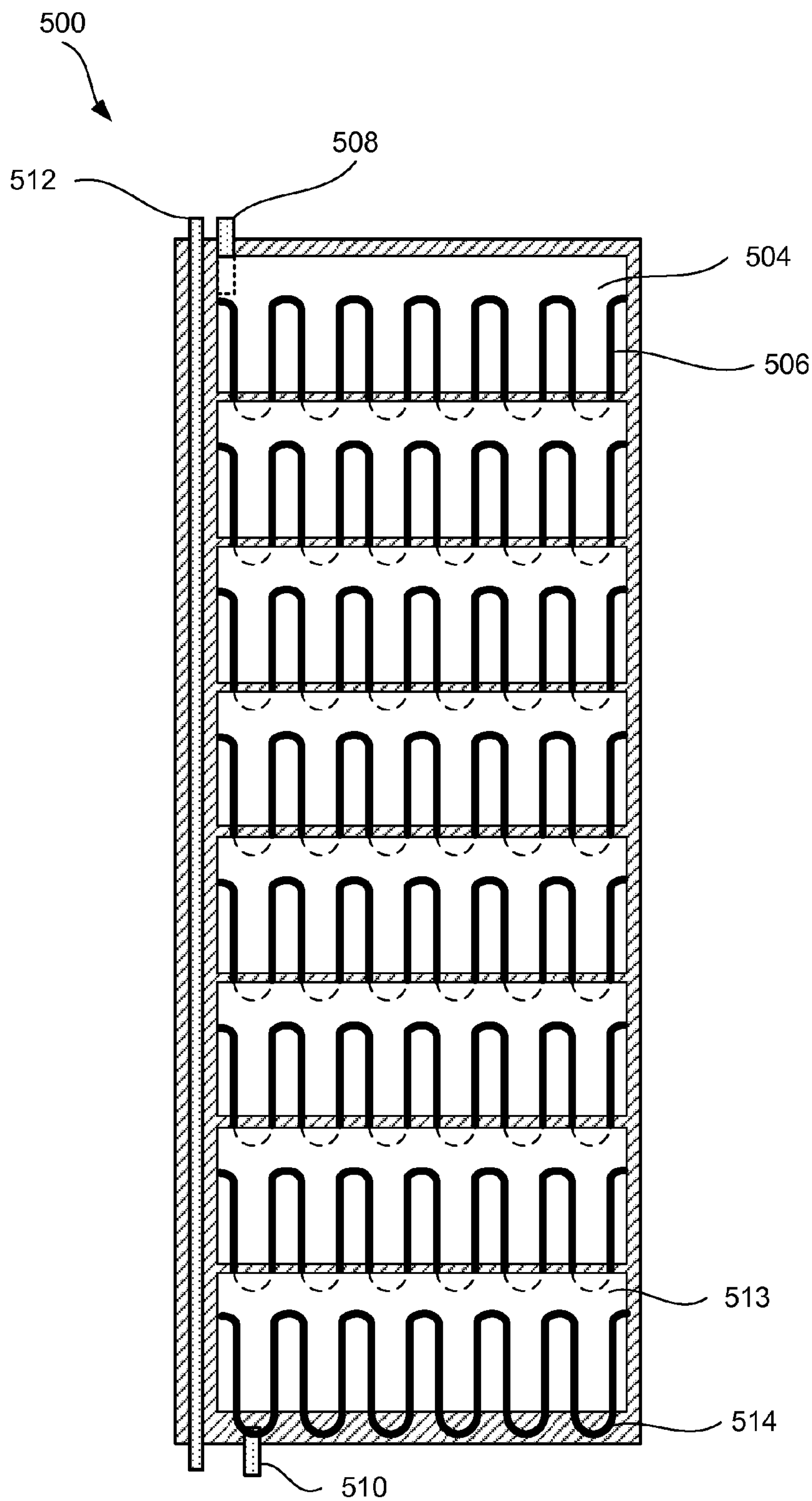


FIG. 5

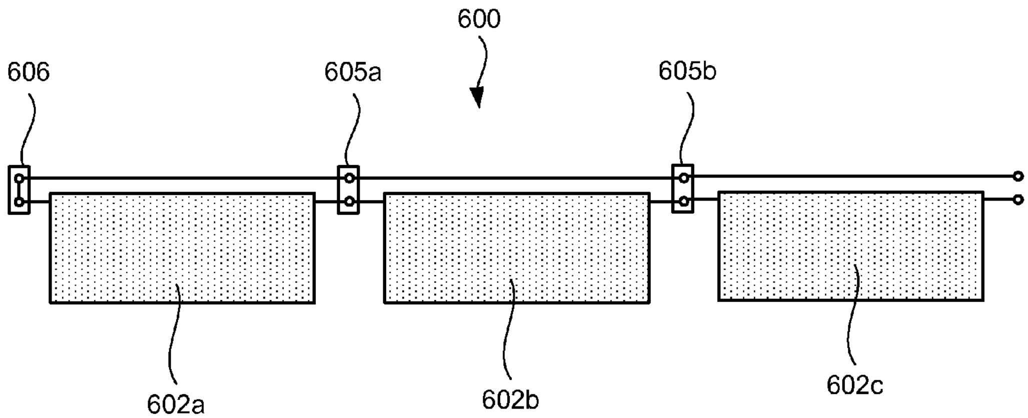

600
606
605a
605b
602a
602b
602c

FIG. 6

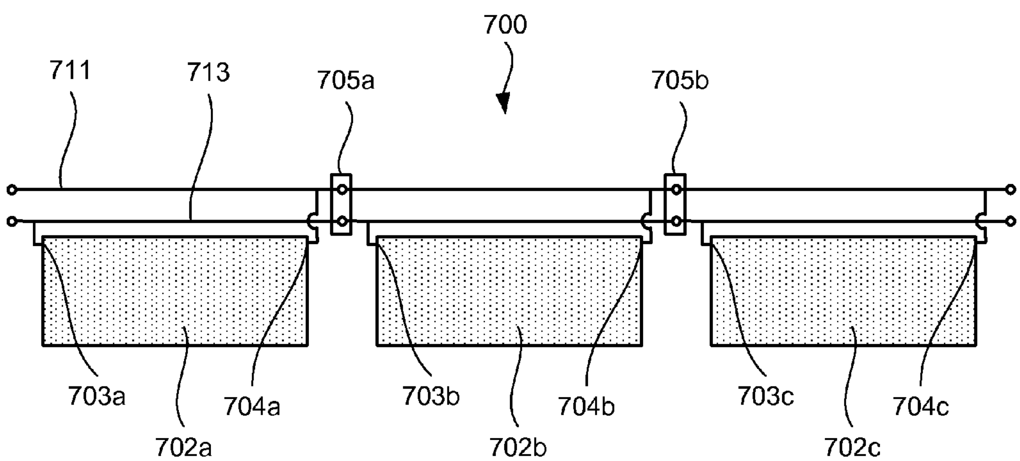

700
711
713
705a
705b
703a
704a
702a
703b
704b
702b
703c
704c
702c

FIG. 7

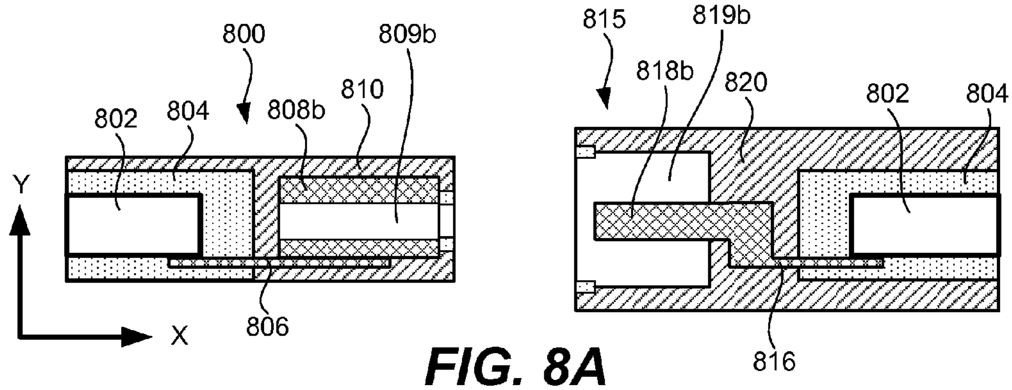


FIG. 8A

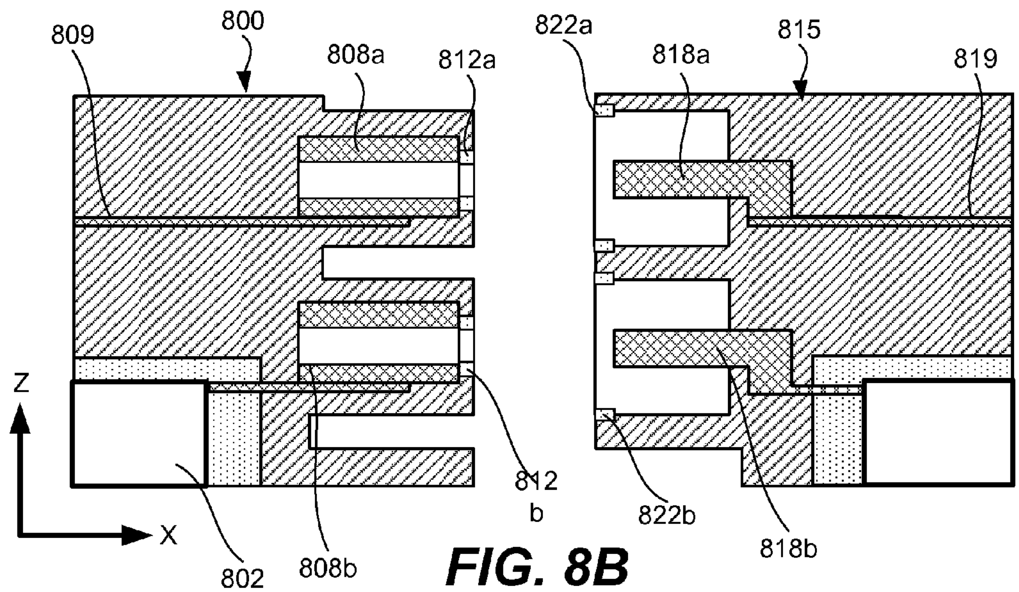


FIG. 8B

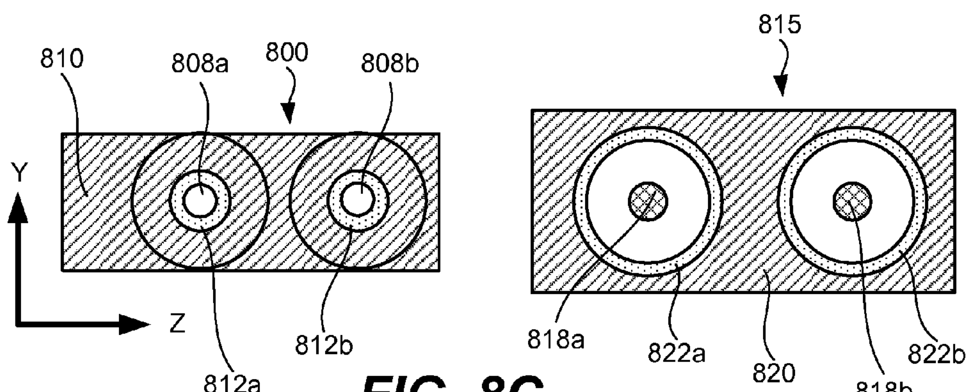


FIG. 8C

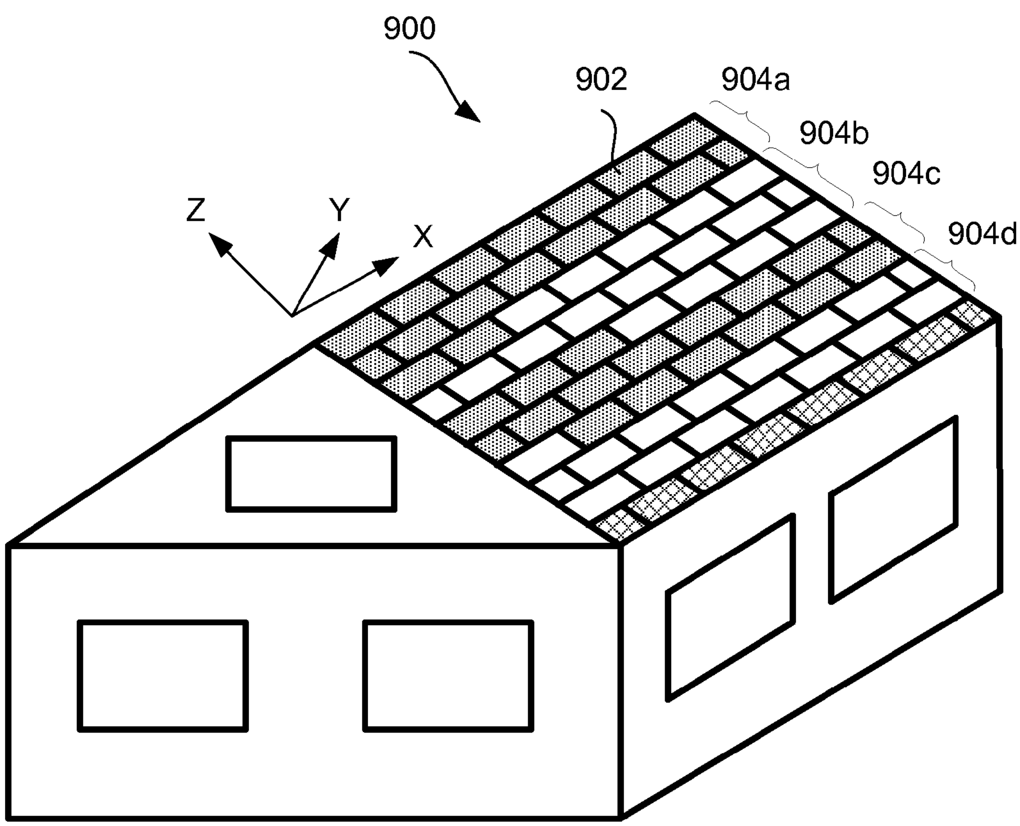


FIG. 9A

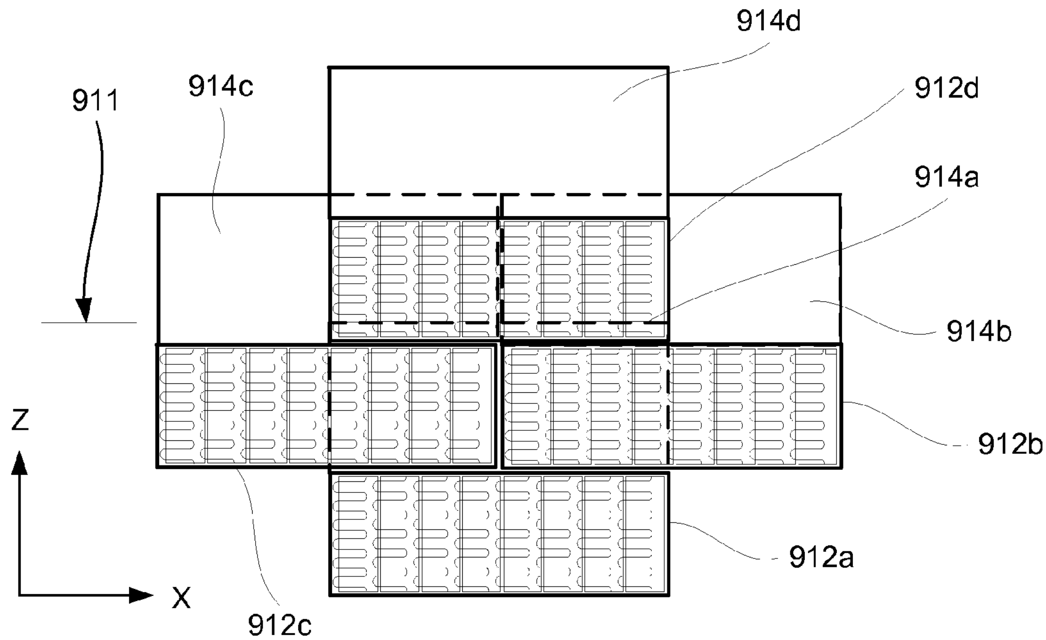

914d
911
914c
912d
914a
914b
Z
912b
X
912a
912c

FIG. 9B

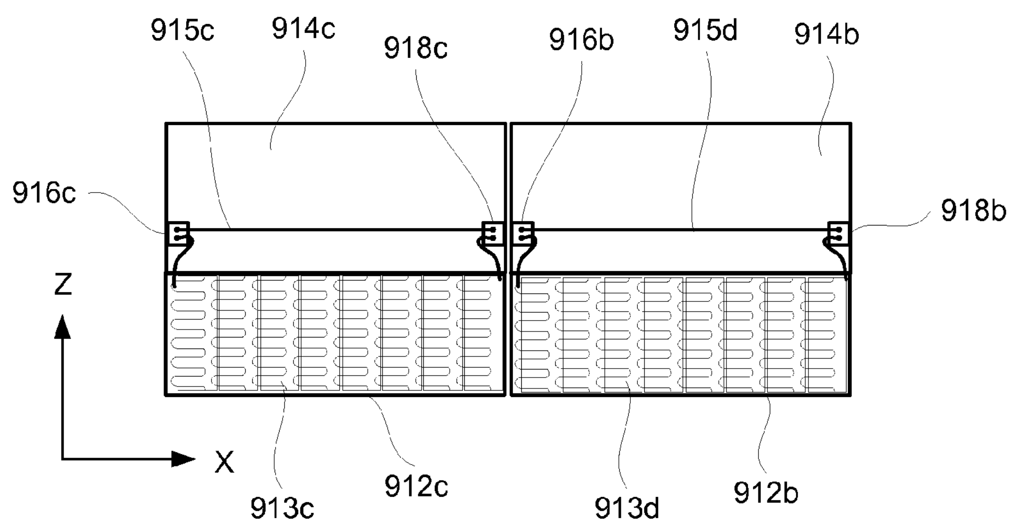

915c
914c
918c
916b
915d
914b
916c
918b
Z
X
913c
912c
913d
912b

FIG. 9C

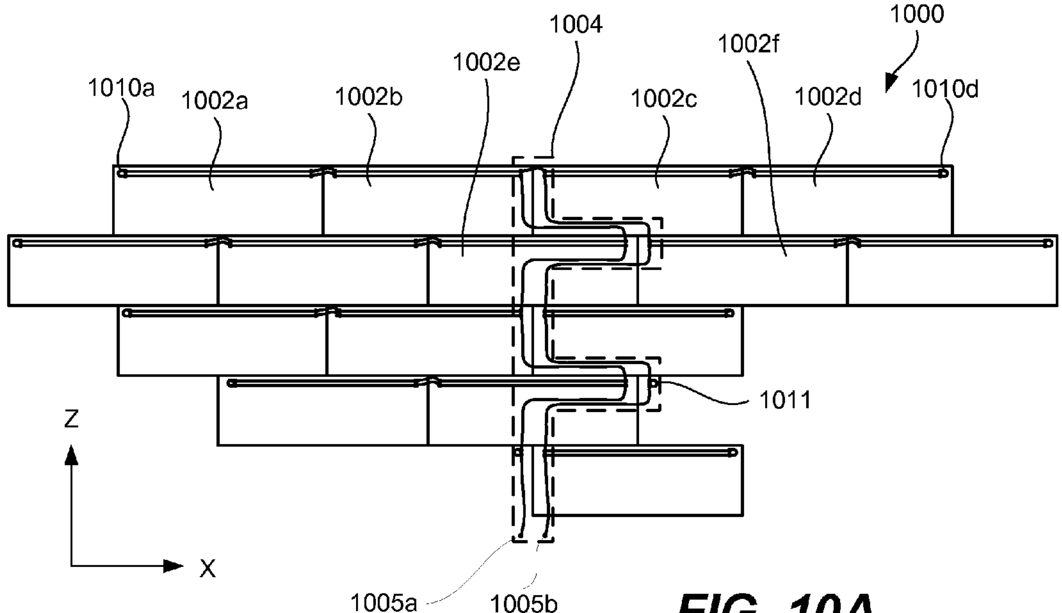

1000
1004
1002f
1002e
1010a
1002a
1002b
1002c
1002d
1010d
1011
Z
X
1005a
1005b

FIG. 10A

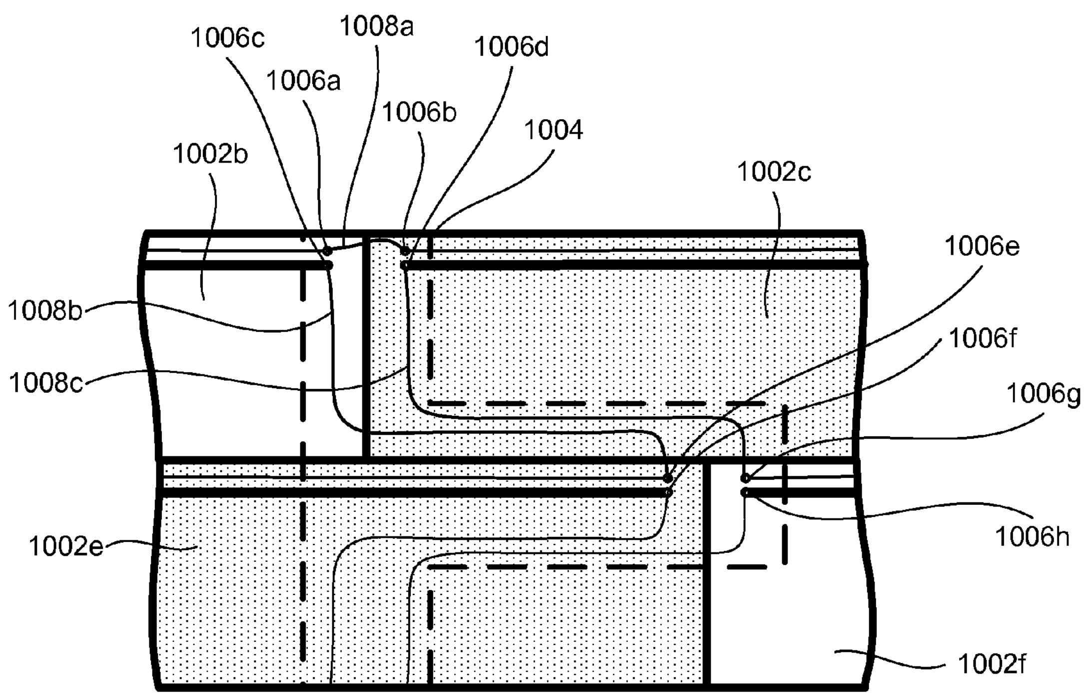

1006c
1008a
1006d
1006a
1006b
1004
1002b
1002c
1006e
1008b
1006f
1008c
1006g
1006h
1002e
1002f

FIG. 10B

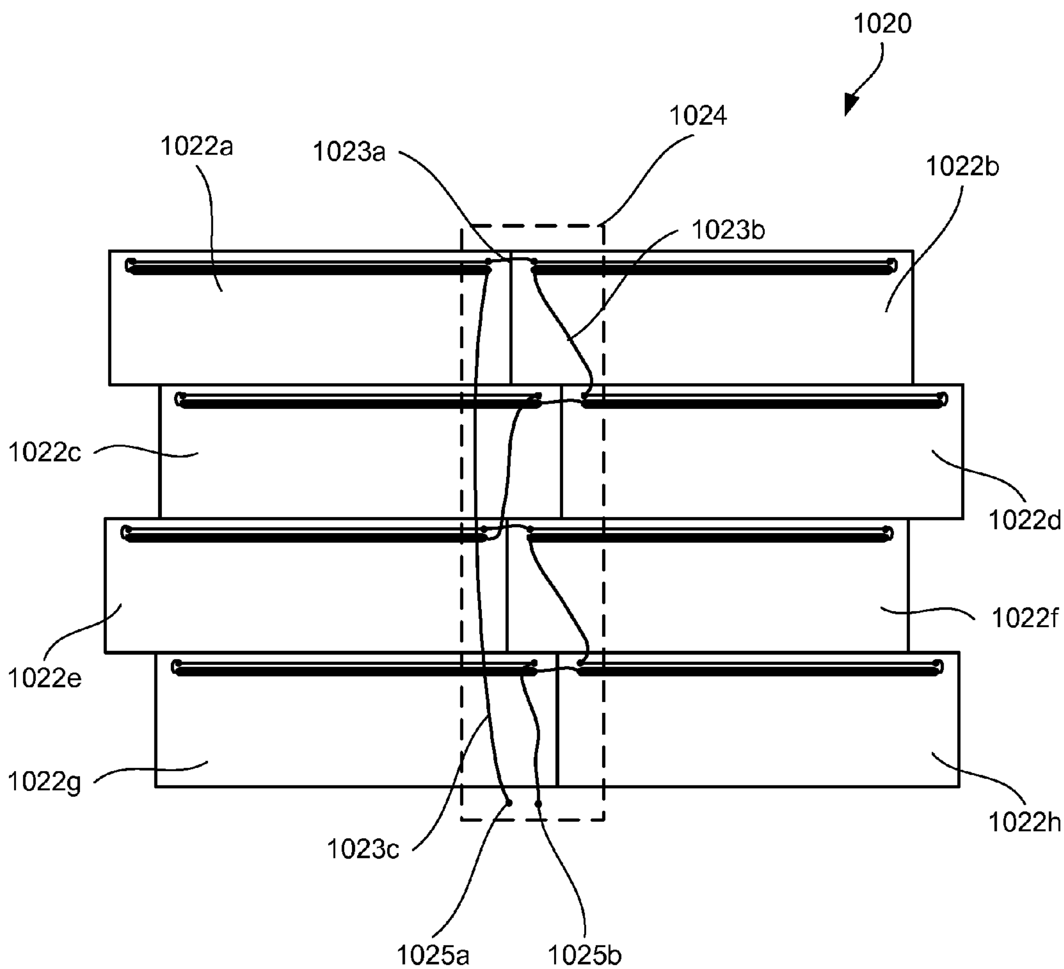

1020
1024
1022a
1023a
1022b
1023b
1022c
1022d
1022f
1022e
1022g
1022h
1023c
1025a
1025b

FIG. 10C

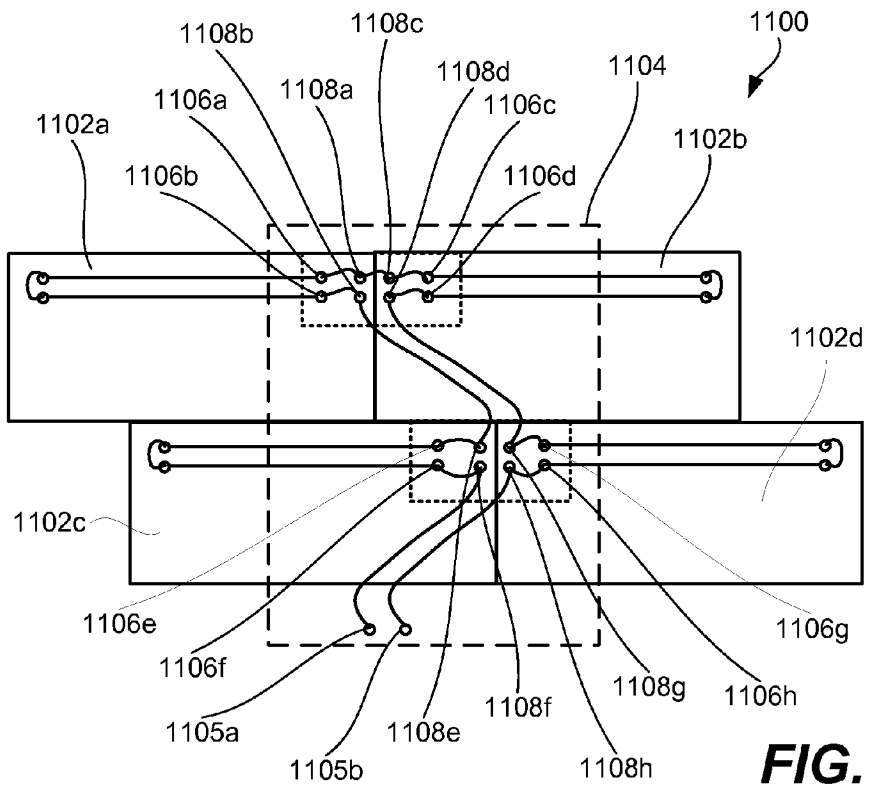


FIG. 11A

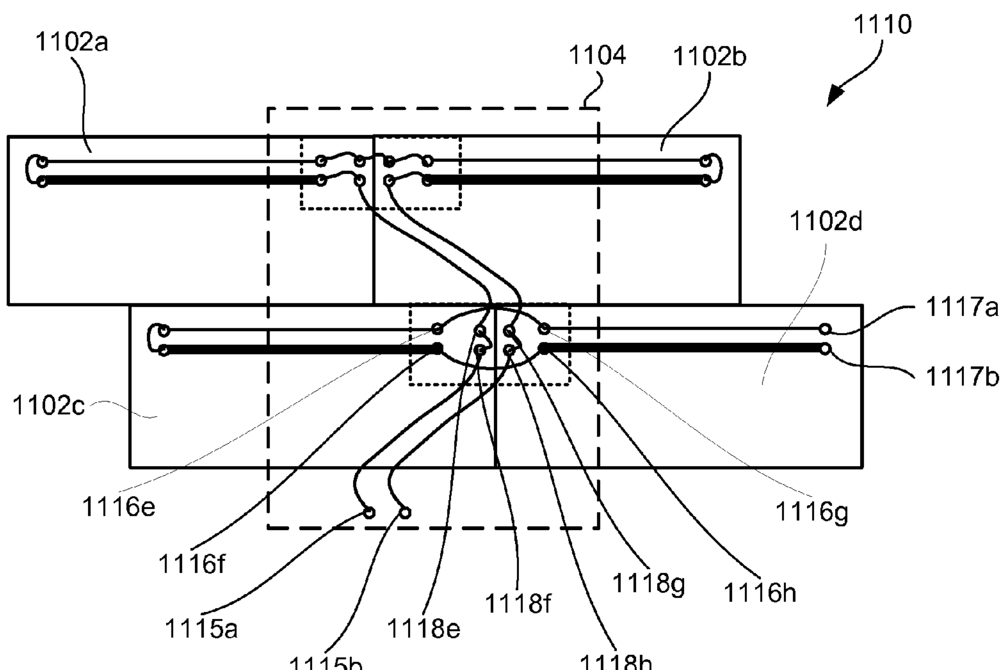


FIG. 11B

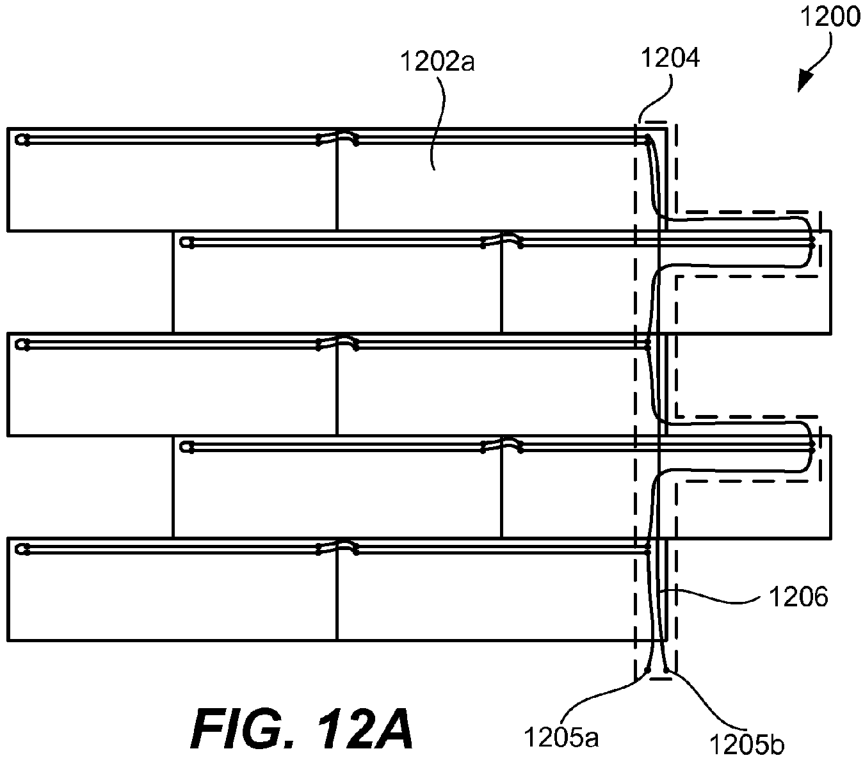


FIG. 12A

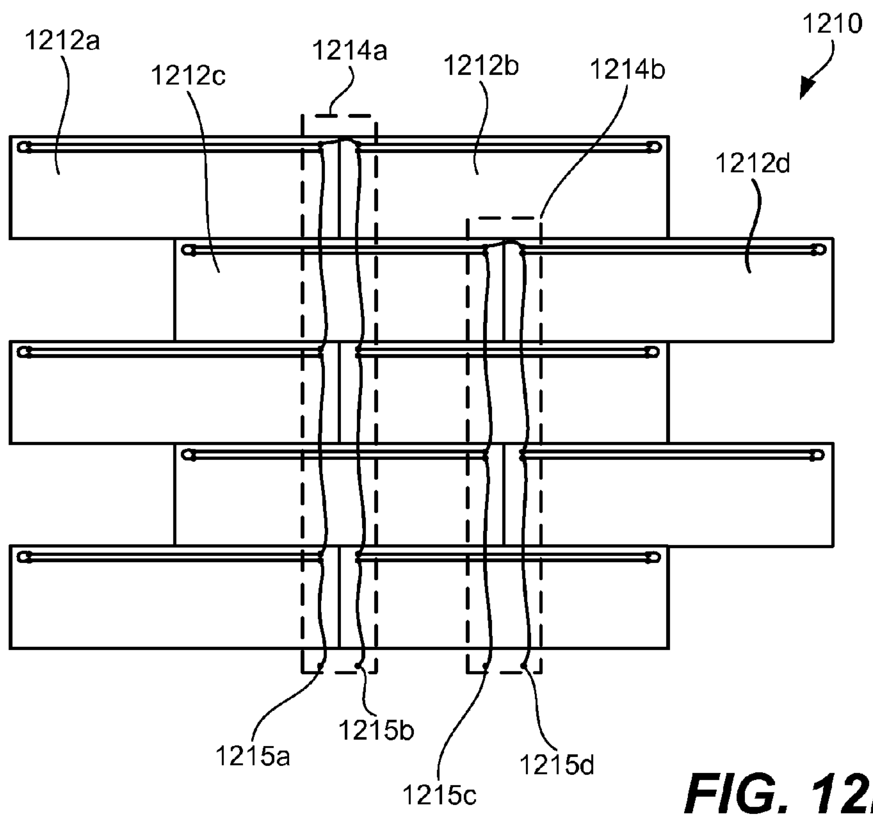


FIG. 12B

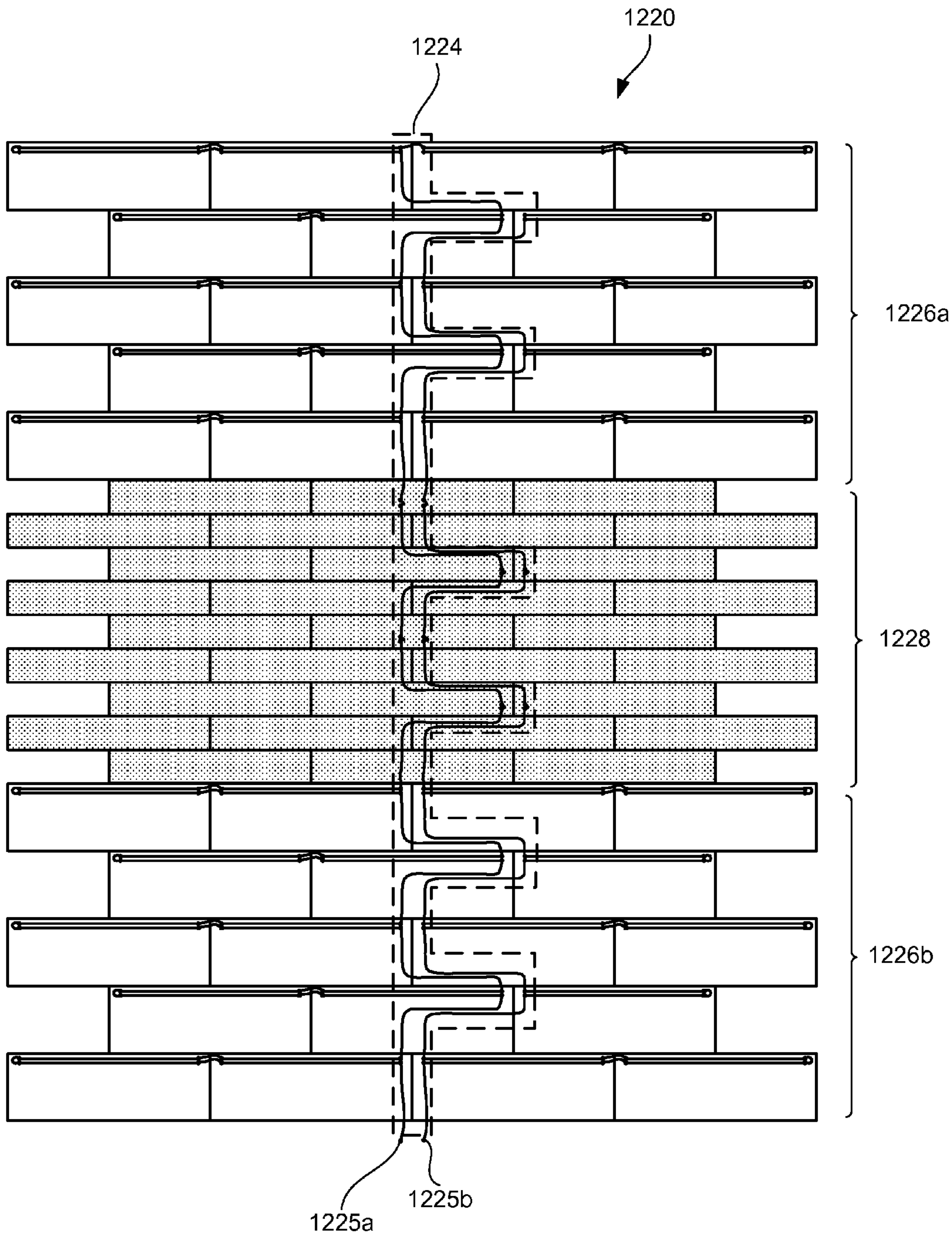


FIG. 12C

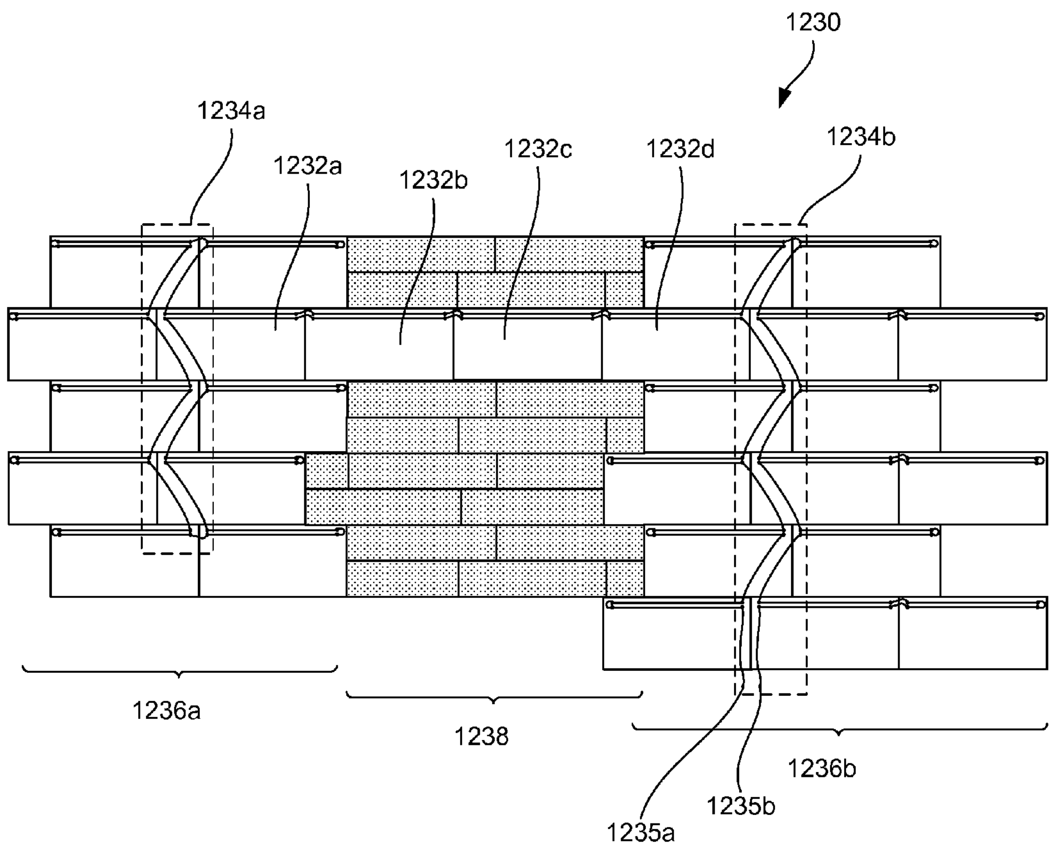

1230
1234a
1232a
1232b
1232c
1232d
1234b
1236a
1238
1236b
1235b
1235a

FIG. 12D

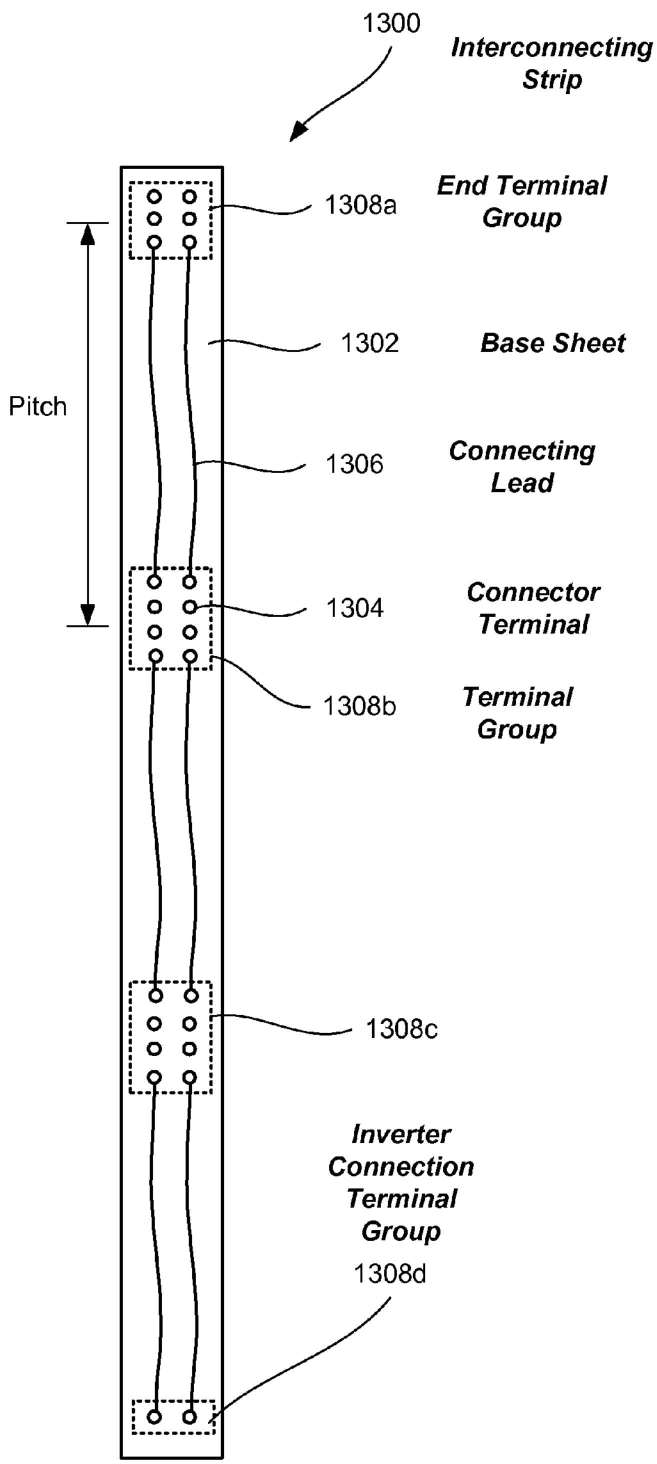


FIG. 13A

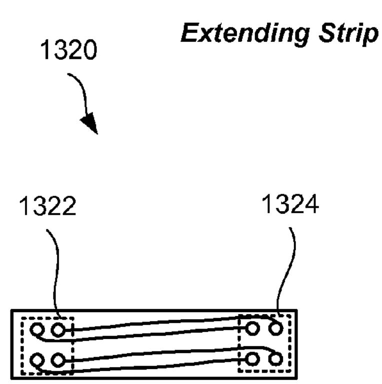


FIG. 13B

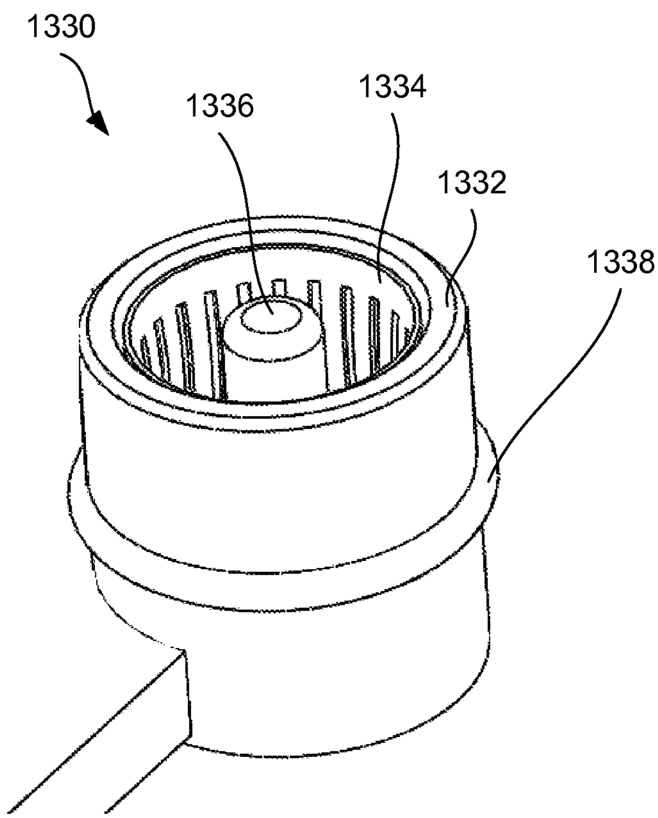


FIG. 13C

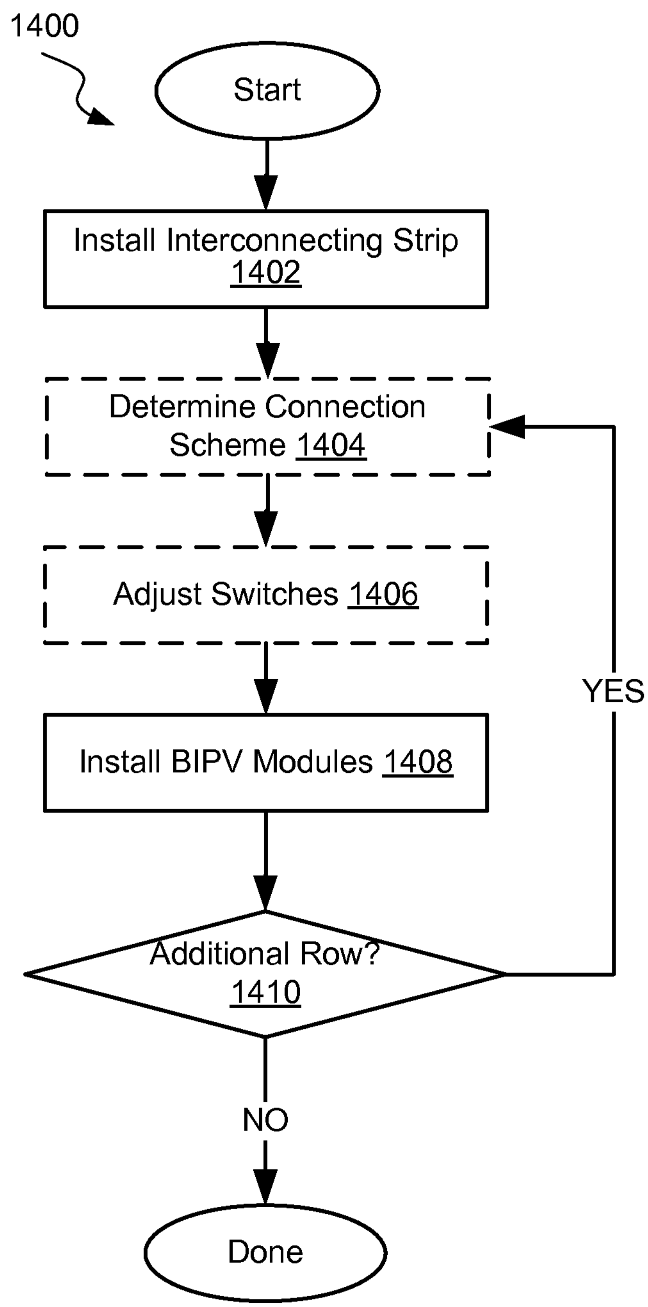

1400
Start
Install Interconnecting Strip 1402
Determine Connection Scheme 1404
Adjust Switches 1406
Install BIPV Modules 1408
Additional Row? 1410
YES
NO
Done

FIG. 14

INTERCONNECTING STRIPS FOR BUILDING INTEGRABLE PHOTOVOLTAIC MODULES

BACKGROUND

Photovoltaic cells are widely used for electricity generation, with one or more photovoltaic cells typically sealed within in a module. Multiple modules may be arranged into photovoltaic arrays used to convert solar energy into electricity by the photovoltaic effect. Arrays can be installed on building rooftops and are used to provide electricity to the buildings and to the general electrical grid. Photovoltaic modules in such arrays often need to be interconnected across multiple rows.

SUMMARY

Provided are novel interconnecting strips for electrically connecting building integrable photovoltaic (BIPV) modules in a photovoltaic array. An interconnecting strip can be provided on a building structure, with electrical connections established by lowering the modules onto the strip during array installation. The strip can include two or more terminal groups, each of which can be aligned with a different row of BIPV modules. Each terminal group can include two or more connector terminals for connecting to the modules in that row. The interconnecting strip can also include leads that connect terminals of different terminal groups. In certain embodiments, terminal groups are offset with respect to adjacent groups to align with BIPV modules that are similarly offset. The interconnecting strip may be reconfigured in the field to provide different electrical connection schemes among BIPV modules.

In certain embodiments, an interconnecting strip for providing electrical connections between BIPV modules arranged in multiple rows includes a base sheet having an insulating material and two or more terminal groups attached to the base sheet and separated by a predetermined distance from each other along a length of the base sheet. Each terminal group may be aligned with a different row of BIPV modules. Furthermore, each terminal group may include at least four connector terminals for connecting to electrical connectors of two adjacent BIPV modules provided in that row. The interconnecting strip may also include two or more connecting leads extending along a length of the base sheet and electrically connected to connector terminals of the two or more terminal groups. In certain embodiments, at least four connector terminals include sockets extending substantially perpendicular to the base sheet. The predetermined distance which separates each pair of adjacent terminal groups may correspond to a width of exposed portions of the BIPV modules.

In certain embodiments, two adjacent terminal groups are offset with respect to each other in a direction along a width of the base sheet. At least one terminal group may include a jumper interconnecting two of the at least four connector terminals. In certain embodiments, all terminal groups of the interconnecting strip may include jumpers interconnecting two of the at least four connector terminals in each terminal group. One or more terminal groups may include integrated switches for changing electrical connections among the at least four connector terminals in the one or more terminal groups. In certain embodiments, one or more terminal groups include at least six connector terminals in the one or more terminal groups. A terminal group may include eight connector terminals, where four connector terminals are configured

for connecting to electrical connectors of two adjacent BIPV modules in the same row and two different connector terminals connected to corresponding two connector terminals in a first terminal group positioned adjacent to the one terminal group. The two remaining connector terminals are connected to corresponding two connector terminals in a second terminal group positioned adjacent to the one terminal group and on another side of the one terminal group along of the length of the base sheet with respect to the first terminal group. In certain embodiments, an interconnecting strip includes a first set of two connector terminals for connecting to electrical connectors of a first BIPV module and a second set of two connector terminals for connecting to electrical connectors of a second BIPV module positioned in the same row with the first BIPV module. The first set of two connector terminals is movable with respect to the second set of two connector terminals at least in a direction along the width of the base sheet.

In certain embodiments, a photovoltaic string includes a first row comprising a first BIPV module and a second BIPV module such that the first BIPV module is not directly connected to the second BIPV module. The photovoltaic string may also include a second row comprising a third BIPV module and an interconnecting strip having a first terminal group aligned with the first row and comprising a first set of connector terminals and a second set of connector terminals. The first set of connector terminals electrically connected to the first BIPV module, while the second set of connector terminals electrically connected to the second BIPV module. The interconnecting strip also includes a second terminal group aligned with the second row and having a third set of connector terminals. The third set of connector terminals is electrically connected to the third BIPV and to the first set of connector terminals. In certain embodiments, at least one connector terminal in the first set is connected to at least another connector terminal in the second set. In the same or other embodiments, the photovoltaic string includes a fourth BIPV module positioned in the second row and not directly connected to the third BIPV module. The interconnecting strip may include a fourth set of connector terminals provided in the second terminal group and attached to the fourth BIPV module and to the second set of connector terminals. In certain embodiments, a photovoltaic string includes a fourth set of connector terminals provided in the second terminal group and attached to the second set of connector terminal such that at least two connector terminals in the fourth terminal group are interconnected.

Provided also is a method of forming a photovoltaic string on a building structure. The method may involve positioning an interconnecting strip on the building structure. The interconnecting strip may include a first terminal group and a second terminal group such that both terminal groups are attached to a base sheet and separated by a predetermined distance from each other along the length of the base sheet. Each terminal group includes at least four connector terminals such that at least two connector terminals in each terminal group are electrically connected to corresponding terminals in one or more adjacent terminal groups. The method may proceed with lowering a first BIPV module onto the interconnecting strip. The first BIPV module may include two contact points on a back side of the first BIPV module. Lowering the first BIPV module onto the interconnecting strip establishes electrical connections between the two contact points of the first BIPV module and two corresponding connector terminals of the first terminal group. In certain embodiments, prior to lowering the first BIPV module onto the interconnecting strip, the method may involve configuring switches of one or more terminal groups to provide a predetermined connection scheme between connector terminals of the interconnecting strip.

In certain embodiments, the method may proceed with lowering a second BIPV module onto the interconnecting strip. The second BIPV module includes two contact points on a back side of the second BIPV module such that lowering this BIPV module onto the interconnecting strip establishes electrical connections between the two contact points of the module and two corresponding connector terminals of the first terminal group. The two corresponding connector terminals of the first terminal group connected to the first BIPV module are different from the two corresponding connector terminals of the first terminal group connected to the second BIPV module. In other embodiments, the method may proceed with lowering a second BIPV module onto the interconnecting strip. The second BIPV module includes two contact points on a back side of the second BIPV module such that lowering the second BIPV module onto the interconnecting strip establishes electrical connections between the two contact points of that module and two corresponding connector terminals of the second terminal group. In certain embodiments, the electrical connections between the two contact points of the second BIPV module and the two corresponding connector terminals of the second terminal group are provided by an extending strip. The extending strip may be attached to the interconnecting strip after positioning the interconnecting strip on the building structure.

These and other embodiments are described further below with reference to the figures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic cross-sectional side view of a BIPV module, in accordance with certain embodiments.

FIG. **2** is a schematic top view of a BIPV module, in accordance with certain embodiments.

FIG. **3** illustrates a subset of a photovoltaic array that includes six BIPV modules, in accordance with certain embodiments.

FIG. **4** is a schematic illustration of a photovoltaic array installed on a rooftop of a building structure, in accordance with certain embodiments.

FIG. **5** is a schematic representation of a photovoltaic module having electrically interconnected photovoltaic cells, in accordance with certain embodiments.

FIG. **6** is a schematic electrical diagram of a photovoltaic array having three BIPV modules interconnected in series, in accordance with certain embodiments.

FIG. **7** is a schematic electrical diagram of a photovoltaic array having three BIPV modules interconnected in parallel, in accordance with other embodiments.

FIGS. **8**A-**8**C are schematic cross-sectional views of two connectors configured for interconnection with each other, in accordance with certain embodiments.

FIG. **9**A is a schematic representation of a photovoltaic array positioned on a rooftop of a building structure, in accordance with certain embodiments.

FIG. **9**B is a schematic representation of four installed modules showing various overlaps between these modules, in accordance with certain embodiments.

FIG. **9**C is a schematic representation of the back sides of the two middle modules presented in FIG. **9**B, in accordance with certain embodiments.

FIG. **10**A is a simplified schematic representation of a string including fifteen BIPV modules electrically connected using an interconnecting strip, in accordance to certain embodiments.

FIG. **10**B is an expanded view of the interface between the interconnecting strip and the top two rows of BIPV modules shown in FIG. **10**A, in accordance with certain embodiments.

FIG. **10**C is a schematic representation of a string including eight modules connected in series with each other using an interconnecting strip, in accordance with certain embodiments.

FIGS. **11**A and **11**B are simplified schematic representations of two photovoltaic arrays each including the same four BIPV modules and interconnecting strip, in accordance with certain embodiments.

FIG. **12**A is a schematic representation of a photovoltaic string including ten BIPV modules connected by an interconnecting strip, in accordance with certain embodiments.

FIG. **12**B is a schematic representation of a string having two interconnecting strips for interconnecting alternate rows of modules in the same string, in accordance with certain embodiments.

FIG. **12**C is a schematic representation of a string including two groups of modules separated by a building component positioned in between the rows, in accordance with certain embodiments.

FIG. **12**D is a schematic representation of another string that has two groups of modules separated in the horizontal direction by a building component, in accordance with certain embodiments.

FIG. **13**A is a schematic representation of an interconnecting strip for electrically connecting multiple rows of BIPV modules, in accordance with certain embodiments.

FIG. **13**B is a schematic representation of an extending strip for connecting to a terminal group of the interconnecting strip and providing an offset connection, in accordance with certain embodiments.

FIG. **13**C is a schematic expanded view of a connector terminal having a socket shape, in accordance with certain embodiments.

FIG. **14** is a flow chart corresponding to a process for forming a photovoltaic string containing multiple rows of interconnected BIPV modules on a building structure, in accordance with certain embodiments.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

In the following description, numerous specific details are set forth in order to provide a thorough understanding of the presented concepts. The presented concepts may be practiced without some or all of these specific details. In other instances, well known process operations have not been described in detail so as to not unnecessarily obscure the described concepts. While some concepts will be described in conjunction with the specific embodiments, it will be understood that these embodiments are not intended to be limiting.

BIPV modules are installed on building structures to provide electrical power and protect the underlying building structures from the environment. BIPV modules can be interconnected in strings, which often include multiple rows of modules. Variations in installation area shapes and obstructions may present additional challenges for interconnecting modules, drive up installation costs (or, more specifically, interconnection costs), and may result in a lower utilization of the available installation area. For example, some rows may need to have different lengths than others. Careful planning of various connections and positions of BIPV modules may be difficult to perform in field conditions. At the same time, information about various aspects of the installation is generally not available in advance.

One factor that presents particular difficulties during the planning and installation of a photovoltaic array is establishing electrical connections across multiple rows of modules that have different lengths. When rows have the same length, end modules may be easily interconnected using various features, such as edge pieces. Such features usually allow for a certain predetermined offset between two rows of equal length but cannot be used when the ends of two adjacent rows are offset by more than this predetermined amount (e.g., when one row is shorter than another). If an array is limited to multiple rows having the same length, then much of the installation area may become unused. Furthermore, a photovoltaic array has a better aesthetic appearance when it conforms to the installation boundary and has a constant offset between the rows of its modules. Additional requirements to the installation and interconnection boundaries may be prescribed by local fire and electrical codes. All of these factors further complicate arranging the BIPV modules and establishing electrical connections among the modules, as described below with reference to FIG. **9**A.

To provide a better understanding of various features of BIPV modules and methods of integrating connectors with photovoltaic inserts during module fabrication, some examples of BIPV modules will now be briefly described. FIG. **1** is a schematic cross-sectional end view (line **1**-**1** in FIG. **2** indicates the position of this cross-section) of a BIPV module **100**, in accordance with certain embodiments. BIPV module **100** may have one or more photovoltaic cells **102** that are electrically interconnected. Photovoltaic cells **102** may be interconnected in parallel, in series, or in various combinations of these. Examples of photovoltaic cells include copper indium gallium selenide (CIGS) cells, cadmium-telluride (Cd—Te) cells, amorphous silicon (a-Si) cells, micro-crystalline silicon cells, crystalline silicon (c-Si) cells, gallium arsenide multi junction cells, light adsorbing dye cells, organic polymer cells, and other types of photovoltaic cells.

Photovoltaic cell **102** has a photovoltaic layer that generates a voltage when exposed to sunlight. In certain embodiments, the photovoltaic layer includes a semiconductor junction. The photovoltaic layer may be positioned adjacent to a back conductive layer, which, in certain embodiments, is a thin layer of molybdenum, niobium, copper, and/or silver. Photovoltaic cell **102** may also include a conductive substrate, such as stainless steel foil, titanium foil, copper foil, aluminum foil, or beryllium foil. Another example includes a conductive oxide or metallic deposition over a polymer film, such as polyimide. In certain embodiments, a substrate has a thickness of between about 2 mils and 50 mils (e.g., about 10 mils), with other thicknesses also in the scope. Photovoltaic cell **102** may also include a top conductive layer. This layer typically includes one or more transparent conductive oxides (TCO), such as zinc oxide, aluminum-doped zinc oxide (AZO), indium tin oxide (ITO), and gallium doped zinc oxide. A typical thickness of a top conductive layer is between about 100 nanometers to 1,000 nanometers (for example, between about 200 nanometers and 800 nanometers), with other thicknesses within the scope.

In certain embodiments, photovoltaic cells **102** are interconnected using one or more current collectors (not shown). The current collector may be attached and configured to collect electrical currents from the top conductive layer. The current collector may also provide electrical connections to adjacent cells as further described with reference to of FIG. **5**, below. The current collector includes a conductive component (e.g., an electrical trace or wire) that contacts the top conductive layer (e.g., a TCO layer). The current collector may further include a top carrier film and/or a bottom carrier film, which may be made from transparent insulating materials to prevent electrical shorts with other elements of the cell and/or module. In certain embodiments, a bus bar is attached directly to the substrate of a photovoltaic cell. A bus bar may also be attached directly to the conductive component of the current collector. For example, a set of photovoltaic cells may be electrically interconnected in series with multiple current collectors (or other interconnecting wires). One bus bar may be connected to a substrate of a cell at one end of this set, while another bus bar may be connected to a current collector at another end.

Photovoltaic cells **102** may be electrically and environmentally insulated between a front sheet **104** (i.e., the light incident sheet) and a back sheet **106** (i.e., the building structure facing sheet), which may be referred to as sealing sheets. Examples of such sheets include glass, polyethylene, polyethylene terephthalate (PET), polypropylene, polybutylene, polybutylene terephthalate (PBT), polyphenylene oxide (PPO), polyphenylene sulfide (PPS) polystyrene, polycarbonates (PC), ethylene-vinyl acetate (EVA), fluoropolymers (e.g., polyvinyl fluoride (PVF), polyvinylidene fluoride (PVDF), ethylene-terafluoethylene (ETFE), fluorinated ethylene-propylene (FEP), perfluoroalkoxy (PFA) and polychlorotrifluoroethane (PCTFE)), acrylics (e.g., poly(methyl methacrylate)), silicones (e.g., silicone polyesters), and/or polyvinyl chloride (PVC), as well as multilayer laminates and co-extrusions of these materials. A typical thickness of a sealing sheet is between about 5 mils and 100 mils or, more specifically, between about 10 mils and 50 mils. In certain embodiments, a back sheet includes a metallized layer to improve water permeability characteristics of the sheet. For example, a metal foil may be positioned in between two insulating layers to form a composite back sheet. In certain embodiments, a module has an encapsulant layer positioned between one or both sheets **104**, **106** and photovoltaic cells **102**. Examples of encapsulant layer materials include non-olefin thermoplastic polymers or thermal polymer olefin (TPO), such as polyethylene (e.g., a linear low density polyethylene), polypropylene, polybutylene, polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polystyrene, polycarbonates, fluoropolymers, acrylics, ionomers, silicones, and combinations thereof.

BIPV module **100** may also include an edge seal **105** that surrounds photovoltaic cells **102**. Edge seal **105** may be used to secure front sheet **104** to back sheet **106** and/or to prevent moisture from penetrating in between these two sheets. Edge seal **105** may be made from certain organic or inorganic materials that have low inherent water vapor transmission rates (WVTR) (e.g., typically less than 1-2 g/m^2/day). In certain embodiments, edge seal **105** is configured to absorb moisture from inside the module in addition to preventing moisture ingression into the module. For example, a butyl-rubber containing moisture getter or desiccant may be added to edge seal **105**. In certain embodiments, a portion of edge seal **105** that contacts electrical components (e.g., bus bars) of BIPV module **100** is made from a thermally resistant polymeric material. Various examples of thermally resistant materials and RTI ratings are further described below.

BIPV module **100** may also have a support sheet **108** attached to back sheet **106**. The attachment may be provided by a support edge **109**, which, in certain embodiments, is a part of support sheet **108**. Support sheets may be made, for example, from rigid polymer materials such as polyethylene terephthalate (e.g., RYNITE® available from Du Pont in Wilmington, Del.), polybutylene terephthalate (e.g., CRASTIN® also available from Du Pont), polyphenylene sulfide (e.g., RYTON® available from Chevron Phillips in The Woodlands, Tex.), polyamide (e.g., ZYTEL® available from DuPont), polycarbonate, and polypropylene. In other embodiments, support sheet **108** may be attached to back sheet **106** without a separate support edge **109** or other separate supporting element. For example, support sheet **108** and back sheet **106** may be laminated together, or support sheet **108** may be formed (e.g., by injection molding) over back sheet **106**. In other embodiments, back sheet **106** serves as a support sheet **108**. In this case, the same element used to seal photovoltaic cells **102** may be positioned over and contact a roof structure (not shown). Support sheet **108** may have one or more ventilation channels **110** to allow for air to flow between BIPV module **100** and a building surface (e.g., a roof-deck or a water resistant underlayment/membrane on top of the roof deck). Ventilation channels **110** may be used for cooling BIPV module **100** during its operation. For example, it has been found that each 1° C. of heating from an optimal operating temperature of a typical Copper indium gallium (di)selenide CIGS cell causes an efficiency loss of about 0.33% to 0.5%.

BIPV module **100** has one or more electrical connectors **112** for electrically connecting BIPV module **100** to other BIPV modules and array components, such as an inverter and/or a battery pack. In certain embodiments, BIPV module **100** has two electrical connectors **112** positioned on opposite sides (e.g., the short or minor sides of a rectangular module) of BIPV module **100**, as shown in FIGS. **1** and **2**, for example. However, connectors may also be positioned on other sides as well (e.g., the long or major sides of a rectangular module). Connector position may depend on the overall arrangement of the module and/or installation and repair requirements. Each one of two electrical connectors **112** has at least one conductive element electrically connected to photovoltaic cells **102**. In certain embodiments, electrical connectors **112** have additional conductive elements, which may or may not be directly connected to photovoltaic cells **102**. For example, each of two electrical connectors **112** may have two conductive elements, one of which is electrically connected to photovoltaic cells **102**, while the other is electrically connected to a bus bar (not shown) passing through BIPV module **100**. This and other examples are described in more detail in the context of FIGS. **6** and **7**. In general, regardless of the number of connectors **112** attached to BIPV module **100**, at least two conductive elements of these connectors **112** are electrically connected to photovoltaic cells **102**.

FIG. **2** is a schematic top view of BIPV module **100**, in accordance with certain embodiments. Support sheet **108** is shown to have a side skirt **204** and a flap portion **206** extending beyond a photovoltaic portion **202** of BIPV module **100**. Side skirt **204** is sometimes referred to as a side flap, while flap portion **206** is sometimes referred to as a top lap or a moisture flap. In certain embodiments, BIPV module **100** does not include side skirt **204**. Photovoltaic portion **202** is defined as an area of BIPV module **100** that does not extend under other BIPV modules or similar building materials (e.g., roofing shingles) after installation. Photovoltaic portion **202** includes photovoltaic cells **102**. Generally, it is desirable to maximize the ratio of the exposed area of photovoltaic cells **102** to photovoltaic portion **202** in order to maximize the "working area" of BIPV module **100**. It should be noted that, after installation, flaps of other BIPV modules typically extend under photovoltaic portion **202**. In a similar manner, after installation, side skirt **204** of BIPV module **100** may extend underneath another BIPV module positioned on the left (in the same row) of BIPV module **100**, thereby creating an overlap for moisture sealing. Flap portion **206** may extend underneath one or more BIPV modules positioned above BIPV module **100**. Arrangements of BIPV modules in an array will now be described in more detail with reference to FIGS. **3** and **4**.

FIG. **3** illustrates a photovoltaic array **300** or, more specifically, a portion of a photovoltaic array, which includes six BIPV modules **100*a*-100*f*** arranged in three different rows extending along horizontal rooflines, in accordance with certain embodiments. Installation of BIPV modules **100*a*-100*f*** generally starts from a bottom roofline **302** so that the top flaps of BIPV modules **100*a*-100*f*** can be overlapped with another row of BIPV modules. If a side flap is used, then the position of the side flap (i.e., a left flap or a right flap) determines which bottom corner should be the starting corner for the installation of the array. For example, if a BIPV module has a top flap and a right-side flap, then installation may start from the bottom left corner of the roof or of the photovoltaic array. Another BIPV module installed later in the same row and on the right of the initial BIPV module will overlap the side flap of the initial BIPV module. Furthermore, one or more BIPV modules installed in a row above will overlap the top flap of the initial BIPV module. This overlap of a BIPV module with a flap of another BIPV module creates a moisture barrier.

FIG. **4** is a schematic illustration of a photovoltaic array **400** installed on a rooftop **402** of a building structure **404** for protecting building structure **404** from the environment as well as producing electricity, in accordance with certain embodiments. Multiple BIPV modules **100** are shown to fully cover one side of rooftop **402** (e.g., a south side or the side that receives the most sun). In other embodiments, multiple sides of rooftop **402** are used for a photovoltaic array. Furthermore, some portions of rooftop **402** may be covered with conventional roofing materials (e.g., asphalt shingles). As such, BIPV modules **100** may also be used in combination with other roofing materials (e.g., asphalt shingles) and cover only a portion of rooftop. Generally, BIPV modules **100** may be used on steep sloped to low slope rooftops. For example, the rooftops may have a slope of at least about 2.5-to-12 or, in many embodiments, at least about 3-to-12.

Multiple BIPV modules **100** may be interconnected in series and/or in parallel with each other. For example, photovoltaic array **400** may have sets of BIPV modules **100** interconnected in series with each other (i.e., electrical connections among multiple photovoltaic modules within one set), while these sets are interconnected in parallel with each other (i.e., electrical connections among multiple sets in one array). Photovoltaic array **400** may be used to supply electricity to building structure **404** and/or to an electrical grid. In certain embodiments, photovoltaic array **400** includes an inverter **406** and/or a battery pack **408**. Inverter **406** is used for converting a direct current (DC) generated by BIPV modules **100** into an alternating current (AC). Inverter **406** may be also configured to adjust a voltage provided by BIPV modules **100** or sets of BIPV modules **100** to a level that can be utilized by building structure **404** or by a power grid. In certain embodiments, inverter **406** is rated up to 600 volts DC input or even up to 1000 volts DC, and/or up to 10 kW power. Examples of inverters include a photovoltaic static inverter (e.g., BWT10240—Gridtec 10, available from Trace Technologies in Livermore, Calif.) and a string inverter (e.g. Sunny Boy® 2500 available from SMA America in Grass Valley, Calif.). In certain embodiments, BIPV modules **100** may include integrated inverters (i.e., "on module" inverters). These inverters may be used in addition to or instead of external inverters. Battery pack **408** is used to balance electric power output and consumption.

FIG. **5** is a schematic representation of a photovoltaic module insert **500** illustrating photovoltaic cells **504** electrically interconnected in series using interconnecting wires **506**, in accordance with certain embodiments. Often individual cells **504** do not provide an adequate output voltage. For example, a typical voltage output of an individual CIGS cell is only between 0.4V and 0.7V. To increase voltage output, photovoltaic cells **504** may be electrically interconnected in series (for example, as shown in FIG. **5**) and/or include "on module" inverters (not shown). Interconnecting wires **506** may also be used to provide uniform current distribution and collection from one or both contact layers.

As shown in FIG. **5**, each pair of photovoltaic cells **504** has one interconnecting wire positioned in between the two cells and extending over a front side of one cell and over a back side of the adjacent cell. For example, a top interconnecting wire **506** in FIG. **5** extends over the front light-incident side of cell **504** and under the back side of the adjacent cell. In the figure, the interconnecting wires **506** also collect current from the TCO layer and provide uniform current distribution, and may be referred to herein as current collectors. In other embodiments, separate components are used for current collection and cell-to-cell interconnection. End cell **513** has a current collector **514** that is positioned over the light incident side of cell **513** but does not connect to another cell. Current collector **514** connects cell **513** to a bus bar **510**. Another bus bar **508** may be connected directly to the substrate of the cell **504** (i.e., the back side of cell **504**). In another embodiment, a bus bar may be welded to a wire or other component underlying the substrate. In the configuration shown in FIG. **5**, a voltage between bus bars **508** and **510** equals a sum of all cell voltages in insert **500**. Another bus bar **512** passes through insert **500** without making direct electrical connections to any photovoltaic cells **504**. This bus bar **512** may be used for electrically interconnecting this insert in series without other inserts, as further described below with reference to FIG. **6**. Similar current collectors/interconnecting wires may be used to interconnect individual cells or set of cells in parallel (not shown).

BIPV modules themselves may be interconnected in series to increase a voltage of a subset of modules or even an entire array. FIG. **6** illustrates a schematic electrical diagram of a photovoltaic array **600** having three BIPV modules **602***a*-**602***c* interconnected in series using module connectors **605***a*, **605***b*, and **606**, in accordance with certain embodiments. A voltage output of this three-module array **600** is a sum of the voltage outputs of the three modules **602***a*-**602***c*. Each module connector **605***a* and **605***b* shown in FIG. **6** may be a combination of two module connectors of BIPV modules **602***a*-**602***c*. These embodiments are further described with reference to FIGS. **8**A-**8**C. In other words, there may be no separate components electrically interconnecting two adjacent BIPV modules, with the connection instead established by engaging two connectors installed on the two respective modules. In other embodiments, separate connector components (i.e., not integrated into or installed on BIPV modules) may be used for connecting module connectors of two adjacent modules.

Module connector **606** may be a special separate connector component that is connected to one module only. It may be used to electrically interconnect two or more conductive elements of the same module connector (e.g., to close an electrical loop in a series of connections).

Sometimes BIPV modules may need to be electrically interconnected in parallel. FIG. **7** illustrates a schematic electrical diagram of a photovoltaic array **700** having three BIPV modules **702***a*-**702***c* interconnected in parallel using module connectors **705***a* and **705***b*, in accordance with certain embodiments. Each module may have two bus bars extending through the module (i.e., a "top" bus bar **711** and a "bottom" bus bar **713**, as shown in FIG. **7**). Top bus bars **711** of each module are connected to right electrical leads **704***a*, **704***b*, and **704***c* of the modules, while bottom bus bars **713** are connected to left electrical leads **703***a*, **703***b*, and **703***c*. A voltage between the top bus bars **711** and bottom bus bars **713** is therefore the same along the entire row of BIPV modules **702***a*-**702***c*.

FIG. **8**A is a schematic cross-sectional side view of two connectors **800** and **815** configured for interconnection with each other, in accordance with certain embodiments. For simplicity, the two connectors are referred to as a female connector **800** and a male connector **815**. Each of the two connectors **800** and **815** is shown attached to its own photovoltaic insert, which includes photovoltaic cells **802** and one or more sheets **804**. Connectors **800** and **815** include conductive elements **808***b* and **818***b*, respectively, which are shown to be electrically connected to photovoltaic cells **802** using bus bars **806** and **816**, respectively.

In certain embodiments, a conductive element of one connector (e.g., conductive element **808***b* of female connector **800**) is shaped like a socket/cavity and configured for receiving and tight fitting a corresponding conductive element of another connector (e.g., conductive element **818***b* of male connector **815**). Specifically, conductive element **808***b* is shown forming a cavity **809***b*. This tight fitting and contact in turn establishes an electrical connection between the two conductive elements **808***b* and **818***b*. Accordingly, conductive element **818***b* of male connector **815** may be shaped like a pin (e.g., a round pin or a flat rectangular pin). A socket and/or a pin may have protrusions (not shown) extending towards each other (e.g., spring loaded tabs) to further minimize the electrical contact resistance by increasing the overall contact area. In addition, the contacts may be fluted to increase the likelihood of good electrical contact at multiple points (e.g., the flutes guarantee at least as many hot spot asperities of current flow as there are flutes).

In certain embodiments, connectors do not have a cavity-pin design as shown in FIGS. **8**A-**8**C. Instead, an electrical connection may be established when two substantially flat surfaces contact each other. Conductive elements may be substantially flat or have some topography designed to increase a contact surface over the same projection boundary and/or to increase contact force at least in some areas. Examples of such surface topography features include multiple pin-type or rib-type elevations or recesses.

In certain embodiments, one or more connectors attached to a BIPV module have a "touch free" design, which means that an installer cannot accidently touch conductive elements or any other electrical elements of these connectors during handling of the BIPV module. For example, conductive elements may be positioned inside relatively narrow cavities. The openings of these cavities are too small for a finger to accidently come in to contact with the conductive elements inside the cavities. One such example is shown in FIG. **8**A where male connector **815** has a cavity **819***b* formed by connector body **820** around its conductive pin **818***b*. While cavity **819***b* may be sufficiently small to ensure a "touch free" designed as explained above, it is still large enough to accommodate a portion of connector body **810** of female connector **800**. In certain embodiments, connector bodies **810** and **820** have interlocking features (not shown) that are configured to keep the two connectors **800** and **815** connected and prevent connector body **810** from sliding outs of cavity **819***b*. Examples of interlocking features include latches, threads, and various recess-protrusion combinations.

FIG. **8**B is schematic plan view of female connector **800** and male connector **815**, in accordance with certain embodiments. Each of the connectors **800** and **815** is shown with two conductive elements, i.e., conductive elements **808***a* and **808***b* formed as sockets in connector **800** and conductive elements **818***a* and **818***b* formed as pins in connector **815**. One conductive element of each connector is shown to be electrically connected to photovoltaic cells **802**. Another conductive element of each of the two connectors **800** and **815** may be connected to bus bars (e.g., bus bars **809** and **819**) that do not have an immediate electrical connection to photovoltaic cells **802** of their respective BIPV module (the extended electrical connection may exist by virtue of a complete electrical circuit).

As shown, conductive elements **808***a* and **808***b* may have their own designated inner seals **812***a* and **812***b*. Inner seals **812***a* and **812***b* are designed to provide more immediate protection to conductive elements **808***a* and **818***a* after connecting the two connectors **800**, **815**. As such, inner seals **812***a* and **812***b* are positioned near inner cavities of conductive elements **808***a* and **808***b*. The profile and dimensions of pins **818***a* and **818***b* closely correspond to that of inner seals **812***a* and **812***b*. In the same or other embodiments, connectors **800**, **815** have external seals **822***a* and **822***b*. External seals **822***a* and **822***b* may be used in addition to or instead of inner seals **812***a* and **812***b*. Various examples of seal materials and fabrication methods are described below in the context of FIG. **9**.

FIG. **8**C is schematic front view of female connector **800** and male connector **815**, in accordance with certain embodiments. Connector pins **818***a* and **818***b* are shown to have round profiles. However, other profiles (e.g., square, rectangular) may also be used for pins **818***a* and **818***b* and conductive elements **808***a* and **808***b*.

FIG. **9**A is a schematic representation of a photovoltaic array **900** positioned on a rooftop of a building structure, in accordance with certain embodiments. Array **900** includes multiple BIPV modules **902** arranged into four photovoltaic strings **904***a*-**904***d* (each shown with different shading). All modules **902** in each string **904***a*-**904***d* are electrically interconnected, but one string is not connected to any other. Electrical connections between two adjacent modules in the same row may be provided by various types of connectors extending between two adjacent connectors of these modules. Some examples of such connectors are described in U.S. patent application Ser. No. 13/046,453, entitled "SEPARABLE FLEXIBLE PHOTOVOLTAIC CONNECTOR," filed on Mar. 11, 2011, which is incorporated herein by reference in its entirety for purposes of describing external connectors.

A string may include more interconnected modules than can fit in a single row. The number of modules in a string may be driven by an overall voltage requirement of the string, operating voltages of each module, installation boundaries, obstacles, and other factors. For example, all four strings **904***a*-**904***d* shown in FIG. **9**A span over three rows. At the same time, strings **904***a*-**904***d* have their end modules at various locations along the X direction, which makes connections between end modules difficult to establish. FIG. **9**A simplifies various complexities involved in the installation of photovoltaic array. These complexities may result in even more variation of end module positions than presented in FIG. **9**A. Conventional techniques and structures used for interconnecting row ends having a predetermined offset cannot be used for such arrays.

Interconnecting strips described herein can include any number of electrical components configured to interconnect BIPV modules in a photovoltaic array. Specifically, an interconnecting strip may include a base sheet made from an insulating material for supporting other components of the strip. During installation, the base sheet is extended across multiple rows of BIPV modules. Two or more terminal groups may be arranged along the length of the base sheet. Each terminal group of the interconnecting strip may be aligned with a different row of BIPV modules during installation. Connector terminals provided in each group are used for making electrical connections to one or more modules in a row or, more specifically, for making electrical connections to one or more contact points of the module connectors. Some connector terminals in different terminal groups are connected using leads for interconnecting BIPV modules in different rows.

Interconnecting strips described herein allow connecting BIPV modules positioned in multiple rows regardless of the rows' lengths and relative positions of end modules. Such interconnecting strips are sometimes referred to as interconnecting ladders, since they include multiple terminal groups positioned at a predetermined distance from each other (similar to the steps of a ladder). Each terminal group is configured to align with a different row of BIPV modules and make electrical connections to one or two modules in that row. These modules may be connected to one or more other modules forming smaller loops that are interconnected into a larger loop/strip by the interconnecting strip. When connections are made to two modules in the same row, these two modules do not have to be previous connected to each other. In certain embodiments, one or more terminal groups are not connected to any modules and may be used to provide electrical connections between adjacent terminal groups.

Two adjacent rows of BIPV modules may be offset with respect to each other for moisture barrier and aesthetic appearance reasons. The connectors of BIPV modules positioned in the two adjacent rows may also be offset. In certain embodiments, two adjacent terminal groups of the interconnecting strip have a corresponding offset to align with the module connectors in two or more adjacent rows. In these embodiments, spacing between two adjacent terminal groups generally corresponds to the width of the exposed portion of the BIPV module. In other embodiments, this spacing can be about twice the width of the exposed portion of the BIPV module, and two interconnecting strips are used for making electrical connections within the same string. Each of the two strips makes electrical connections to every other row in which module connectors are aligned. The two strips are offset with respect to each other to compensate for any offset between adjacent rows. The two strips are also electrically connected to each other. In yet other embodiments, one or more extending strips are used to compensate for any offset between adjacent rows, as further described below.

Each terminal group of an interconnecting strip may be connected to one or two modules in one row. These modules may be further connected to additional modules in that row forming one or two loops on each side of the terminal group. Typically, these modules have two contact points on each side of the module. One of these two contact points is connected to a return path, while another is connected to one or more photovoltaic cells in the module. When modules positioned in the same row are interconnected in series, the contact points of one module are connected to the corresponding two contact points of an adjacent module and so on. To form a loop, the remaining two contact points of an end module are interconnected such that the return path of the module is connected in series with the photovoltaic cells of the module. (Such interconnection of two contact points of the same connector may be also be referred to as jumping of the connector and may be performed using a device called a jumper. An example of jumper interconnecting two contact points of a connector is jumper **1010**A shown in FIG. **10**A. Jumpers may be also used for making electrical connections between two or more connector terminals of the same terminal group in an interconnecting strip, such as jumper **1008***a* shown in FIG. **10**B, which interconnects terminals **1006***a* and **1006***b*.) The other end of the loop is connected to the strip. Each terminal group of the strip may be connected to two such loops, and each loop may include any number of interconnected modules. In certain embodiments, a loop contains no modules and has only a jumper for interconnecting two connector terminals that would otherwise be used for making electrical connections to contact points of a module, such as jumper **1011** shown in FIG. **10**A. Besides connections between modules of the loops as well as a jumper on one end and connections to a strip on another end, a loop generally does not have any additional connections. However, in certain embodiments, a loop may include a connection to an inverter and/or a connection to another interconnecting strip as further explained below with reference to FIG. **12**D.

An interconnecting strip can be configured to extend across multiple rows and under the BIPV modules (i.e., in between the modules and the building structure). This positioning of the strip helps to protect the strip and electrical connections between the strip and modules from the environment. To make electrical connections to the strip, contact points of the BIPV modules can be provided on the back sides of the modules in a location that does not overlap with other BIPV modules. Generally, this location corresponds to a selected part of the flap that is separated from the photovoltaic portion by a predetermined distance.

To provide a better understanding of overlaps and interferences between BIPV modules during and after installation of the array, a schematic representation of four installed modules showing various overlaps between these modules is provided in FIG. **9**B. Each of these BIPV modules includes a photovoltaic portion (elements **912***a*-**912***d*) containing one or more photovoltaic cells and a flap portion (elements **914***a*-**914***d*) attached to the flap portion and extending under photovoltaic portions of two adjacent modules. Specifically, a flap portion **914***a* (shown with a dotted line as it is completely covered by other modules in this view) extends under photovoltaic portions **912***b* and **912***c* to protect an interface between these two photovoltaic portions. Generally, some small gap exists between two adjacent modules, and an overlap between a flap portion of the module in the adjacent row and two photovoltaic portions of the adjacent modules helps to seal that gap. The flap portion also extends slightly beyond the photovoltaic portion and under another module in the third row to fully seal the gap. In the example shown in FIG. **9**B, flap portion **914***a* extends to level **911** (shown on the left) and under some of photovoltaic portion **912***d*. Therefore, there is also some overlap between flap portion **914***a* and flap portions **914***b* and **914***c* below level **911**. As such, to avoid interference with flap portion **914***a*, contact points of the two middle BIPV modules are positioned on the back sides of their respective flap portions **914***b* and **914***c* above level **911** (i.e., these contact points have a predetermined offset in the Z direction from photovoltaic portions **912***b* and **912***c*). For clarity, various electrical components of these modules are not shown in FIG. **9**B and will not be explained in more detail with reference to FIG. **9**C.

FIG. **9**C is a schematic representation of the back sides of the two middle modules presented in FIG. **9**B, in accordance with certain embodiments. Specifically, FIG. **9**C illustrates the positions of connectors **916***b* and **918***b* on flap portion **914***b* and the positions of connectors **916***c* and **918***c* on flap portion **914***c*. As stated above, these connectors or, more specifically, their contact points are positioned at a predetermined distance in the Z direction from photovoltaic portions **912***b* and **912***c*.

One contact point of each connector **916***b*, **918***b*, **916***c*, and **918***c* is shown connected to the photovoltaic cells **913***c* and **913***d* of their respective modules, while another contact point is shown connected to return paths **915***c* and **915***d*. A return path may extend along the length of each module in the X direction and interconnect two corresponding contact points on each side of the module. Before installation, the return path is not connected to any other components of the module. When these two modules are provided adjacent to each other in a row, respective contact points of connectors **916***b* and **918***c* may be interconnected using an internal or external connector. Specifically, contact points connected to photovoltaic cells **913***c* and **913***d* may be interconnected with each other, while contact points connected to return paths **915***c* and **915***d* may be separately interconnected with each other thereby establishing two separate sets of independent connections. Alternatively, contact points of connectors **916***b* and **918***c* may be connected to respective connector terminals of the same terminal group of an interconnecting strip. Furthermore, when these two modules belong to two different strings, the two contact points of each one of these two connectors are interconnected but no connections are provided between the two connectors. Alternatively, contact points of one or both connectors may be connected to an inverter. Some of these embodiments are further explained below with reference to various string configurations having multiple BIPV modules connected using interconnecting strips.

FIG. **10**A is a simplified schematic representation of a string **1000** including fifteen BIPV modules electrically connected using an interconnecting strip **1004**, in accordance to certain embodiments. For simplicity, photovoltaic and flap portions are not specifically identified. Photovoltaic cells are also not shown. Instead, one of the lines extending between two connectors represents a set of photovoltaic cells, while another line represents a return path. Furthermore, location of module connectors, particularly in the Z direction, is not precisely defined and is presented for illustrative purposes only. For example, connectors may be positioned under the flap portions as it has been described above. The modules shown in FIG. **10**A and other following figures may correspond to the one shown in FIGS. **9**A and **9**B.

String **1000** extends over five rows, with each row having different number and/or arrangement of BIPV modules. In general, a string may have any number of modules, rows of modules, and various kinds of arrangements of the modules in each row. In the example illustrated in FIG. **10**A, the top first row includes four modules **1002***a*-**1002***d*. These four modules form two substrings, each having two interconnected modules. Specifically, the left substring includes modules **1002***a* and **1002***b*, while the right substring includes modules **1002***c* and **1002***d*. Each of the two substrings is independently connected to interconnecting strip **1004**. Modules in each substring are interconnected using, for example, various internal or external connectors. End contact points of each of end modules **1002***a* and **1002***d* are interconnected at their free ends by, for example, jumpers **1010***a* and **1010***d*, respectively. In this manner, the left and right substrings each form a small loop on each side of interconnecting strip **1004**, and interconnecting strip **1004** connects all of these small loops into a common loop. In a similar manner, two right terminals of module **1002***e* represent ends of a left loop in the second row including three modules, which is also connected to interconnecting strip **1004**. Two left terminals of module **1002***f* represent ends of a right loop in the second row including three modules, which is also connected to interconnecting strip **1004**. Similar connections are provided in the third, fourth, and fifth rows.

Each loop may have any number of modules or no modules at all. For example, a right loop in the fourth row includes one jumper **1011** but no modules. Furthermore, any one of these loops may have an inverter connection. FIG. **10**A depicts inverter connections **1005***a* and **1005***b*, for example. In some embodiments, one inverter can be provided per each string. The inverter connection may be provided at any point along the string between terminals or contact points that otherwise would have been interconnected. For example, a jumper of any end module may be replaced with inverter connections, while inverter connections **1005***a* and **1005***b* shown in FIG. **10**A may be interconnected. For clarity, inverter connections **1005***a* and **1005***b* are shown as separate terminals on the interconnecting strip. However, it is understood that a string can represent a continuous loop of interconnected modules with an inverter connection provided anywhere along this loop. In some embodiments, inverter connections can be moved along the loop by interconnecting the original inverter connections and disconnecting any two previously connected terminals and/or contact points to form new inverter connections.

Electrical connections between the top two rows of BIPV modules shown in FIG. **10**A will now be explained in more detail with reference to FIG. **10**B, which is an expanded view of the interface between interconnecting strip **1004** and the top two rows of BIPV modules, in accordance with certain embodiments. Two right terminals **1006***a* and **1006***c* of module **1002***b* represent the ends of one loop (i.e., the left first-row loop) that includes modules **1002***b* and **1002***a* (module **1002***a* is not shown in FIG. **10**B). Two left terminals **1006***b* and **1006***d* of module **1002***c* represent the ends of another loop (i.e., the right first-row loop) that includes modules **1002***c* and **1002***d* (module **1002***d* is not shown in FIG. **10**B). Interconnecting strip **1004** includes terminals that overlie and connect to each of the terminals **1006***a*-**1006***h* of the modules **1002***b*, **1002***c*, **1002***e*, and **1002***f*. Interconnecting strip **1004** may include a jumper **1008***a* between terminals **1006***a* and **1006***b* to interconnect these two loops into a larger first-row loop that includes all modules in that row. Alternatively, jumper **1008***a* may be installed onto interconnecting strip **1004** or modules **1002***b* and **1002***c* during installation of the array. The end connections (which may be also referred as an opening) to this loop is represented by terminals **1006***c* and **1006***d*. Jumper **1008***a* thereby integrates all the modules in the first row. An end row in a string can have a corresponding jumper provided on the interconnecting strip, as will be further evident from FIGS. **10**C, **11**A-**11**B, and **12**B-**12**D. The end-of-the-row jumpers may be preinstalled onto the end modules or provided during installation of the array.

To form electrical connections between the first row and second row, interconnecting strip **1004** includes two connecting leads **1008***b* and **1008***c*. Specifically, connecting lead **1008***b* connects terminal **1006***c* of module **1002***b* with terminal **1006***e* of module **1002***e*. Likewise, connecting lead **1008***c* connects terminal **1006***d* of module **1002***c* with terminal **1006***g* of module **1002***f*. It should be noted that two right terminals **1006***e* and **1006***f* represent the ends of another loop that includes the left three modules in the second row, while two left terminals **1006***g* and **1006***h* represent the ends of yet another loop that includes the right two modules in that row. At the same time, terminals **1006***c* and **1006***d* represent end connections of the first row common loop. Therefore, interconnecting terminals **1006***c* and **1006***d* with terminals **1006***e* and **1006***g* using connecting leads **1008***b* and **1008***c*, respectively, effectively unites the first row common loop with the two loops in the second row and forms a new first-and-second row common loop having end connections provided by terminals **1006***f* and **1006***h*.

Returning to FIG. **10**A, similar connection schemes are applied to the remaining three rows. Specifically, each row is connected with an adjacent row by a set of two connecting leads, thereby integrating side loops into the overall common loop, which represents an entire string when all five rows are interconnected. The last (fifth) row is shown with two connecting leads extending to inverter connections **1005***a* and **1005***b*, which represent the opening to the entire string **1000**. In other embodiments, two terminals of the last row may be interconnected similar to terminals **1006***a* and **1006***b* in the first row (FIG. **10**B), with inverter connections provided at any other connections along the loop, according to the desired embodiment.

A group of terminals of the interconnecting strip that corresponds to one row of modules is referred herein as a terminal group. A number of terminals in each group may vary. Specifically, this number may depend on types of connectors provided on BIPV modules (e.g., two contact point connectors), a number of modules to be connected to each terminal group (e.g., one or two), switching capabilities of the terminal group as further described below with reference to FIGS. **11**A and **11**B, and other factors. In certain embodiments, one or more terminal groups have two connector terminals each as, for example, shown in FIG. **12**A, described further below. This type of terminal group may be used for making electrical connections to a single module having two contact points. An interconnecting strip having such terminal groups may be used for interconnecting multiple rows of modules by making connections to end modules in these rows. In the same or other embodiments, one or more terminal groups may have four connector terminals each. In the example of FIG. **10**B, a terminal group of interconnecting strip **1004** has four connector terminals. One terminal group includes terminals to connect to terminals **1006***a*-**1006***d* of modules **1002***b* and **1002***c*, for example. This type of terminal group may be used for making electrical connections to two modules, with each having two contact points. An interconnecting strip having such terminal groups may be used for interconnecting multiple rows of modules by making connections anywhere along the length of these rows. In the same or other embodiments, one or more terminal groups may have six connector terminals (for example, the top terminal group in FIG. **13**) and/or eight connector terminals (as, for example, shown FIGS. **11**A and **11**B). This type of terminal group may have switching capabilities, which allows for changing the configurations and connection schemes provided by these terminal groups in the field. These examples are described below in more detail with reference to FIGS. **11**A and **11**B.

As shown in FIGS. **10**A and **10**B, two adjacent terminal groups of an interconnecting strip **1004** may be offset with respect to each other in the X direction (i.e., along the length of the module rows or along the width of interconnecting strip **1004**). This offset may accommodate an offset between modules in adjacent rows or, more specifically, may accommodate an offset of their connectors. Modules can be offset for sealing and aesthetic reasons. In certain embodiments, this offset is about half of the module's length (i.e., the size of the module in the X direction) or about a third of the module's length. However, other offset values may be used as well.

To support multiple terminal groups having such offsets, a sufficiently wide interconnecting strip may be provided. Alternatively, one terminal group may be provided on a main portion, which may be referred to as a trunk of the interconnecting strip, while another group may be provided on an extending arm and may be referred to as a branch attached to the main portion as, for example, shown with dotted lines in FIGS. **10**A and **10**B. In certain embodiments, an extending arm may be separable from the main portion as further explained with reference to FIG. **13**B. In other embodiments further described below with reference to FIG. **12**B, two interconnecting strips can be used for interconnecting alternate rows (i.e., one strip is used for making connections to the first, third, and/or fifth rows and so on, while another strip is used for making connections to the second, fourth, and/or six rows and so on). Since the first, third, and/or fifth rows are not offset with respect to each other, the first interconnecting strip may have all of its terminal groups in line. Likewise, the second, fourth, and/or six rows are not offset, and the second interconnecting strip may have all of its terminal groups in line. However, the two strips are offset with respect to each other to accommodate an offset between adjacent rows.

In certain embodiments, two interconnecting strips are connected to each other to extend the length of the strip. For example, an interconnecting strip may have one or two pairs of terminal connectors on one or both of its ends (along the length of the strip) for connecting to other strips or making electrical connections to inverters.

Interconnecting strips may be used to provide different interconnecting schemes. One example is presented in FIGS. **10**A and **10**B, while another is illustrated in FIG. **10**C. Instead of using two connecting leads for interconnecting two adjacent terminal groups, only one lead may be used. Another connection is provided by an overall connecting lead extending between two end terminal groups or between one end terminal group and an inverter connection. This overall connecting lead may be referred to as a vertical return path to distinguish it from the horizontal return paths provided by modules. In certain embodiments, the overall connecting lead may be provided by interconnecting multiple smaller connecting leads. Each one of these smaller leads may extend between two adjacent terminal groups similar to leads **1008***b* and **1008***c* in FIG. **10**B. However, unlike leads **1008***b* and **1008***c* in FIG. **10**B, these smaller leads are connected to each other and to module connectors.

In an example, FIG. **10**C illustrates a string **1020** including eight modules **1022***a*-**1022***h* connected in series with each other using an interconnecting strip **1024**, in accordance with certain embodiments. For simplicity, FIG. **10**C illustrates two modules in each row. End terminals of each of these modules are interconnected at the module's free end. In this manner, each module forms a smaller loop connected to interconnecting strip **1024** that aggregates these eight smaller loops into string **1020**. Each of these smaller loops may have any number of modules or no modules at all. Furthermore, interconnecting strip **1024** may be used for connecting any number of rows.

Top contact points of modules **1022***a* and **1022***b* are interconnected using jumper **1023***a* that may be a part of interconnecting strip **1024** or provided as a separate component. The interconnection of two contact points in the first row is similar to other examples presented elsewhere in this document. As elsewhere, bottom v. top references as applied to contact points are arbitrary and by no means limiting to physical orientation of the actual connector elements of these modules. A bottom contact point of module **1022***a* is connected to one end of an overall connecting lead **1023***c*, which is a part of interconnecting strip **1024**. The other end of this lead may be connected to an inverter connection **1025***a* as shown in FIG. **10**C or to one of the contact points of the module in the bottom row (i.e., if inverter connections are provided at some other point in the string). A bottom contact point of module **1022***b* is connected to a top contact point of module **1022***d* using an internal lead **1023***b* of interconnecting strip **1024**. Using interconnecting strip **1024**, module **1022***d* has its bottom contact point connected to a bottom contact point of module **1022***c*. These connections form a loop including four modules **1022***a*-**1022***d* between the bottom contact points of module **1022***a* (or inverter connection **1025***a*) and the bottom contact point of module **1022***c*.

Continuing down the rows of string **1020**, a top contact point of module **1022***c* is connected to a bottom contact point of module **1022***e*, and top contact points of modules **1022***e* and **1022***f* are interconnected. These connections add two more modules to the loop, which now has six modules **1022***a*-**1022***f* between the bottom contact point of module **1022***a* (or inverter connection **1025***a*) and a bottom contact point of module **1022***f*. The bottom contact point of module **1022***f* is connected to a top contact point of module **1022***h*, while the bottom contact points of modules **1022***g* and **1022***h* are also interconnected. A top contact point of module **1022***g* may be connected to another inverter connection **1025***b* (as shown in FIG. **10**C) to form a loop including all eight modules **1022***a*-**1022***h* between inverter connections **1025***a* and **1025***b*. Alternatively, the top contact points of modules **1022***g* and **1022***h* may be interconnected and inverter connections may be provided at any other points of string **1020**.

To provide additional flexibility during installation of a photovoltaic string, an interconnecting strip may include various switches or jumpers that allow for changing connections between different terminals of the interconnecting strip. Switches and jumpers can be adjusted (e.g., added or removed, moved to a different position) to form new electrical connections and disconnect previous connections in the field as needed. Two examples of such jumpers are presented in FIGS. **10**B and **10**C, i.e., elements **1008***a* and **1023***a* respectively, which can be separate components provided during installation of the photovoltaic array. Other examples of switches and jumpers will now be described in more detail with reference to FIGS. **11**A and **11**B.

FIGS. **11**A and **11**B are simplified schematic representations of two photovoltaic arrays **1100** and **1110** including the same four BIPV modules **1102***a*-**1102***d* and interconnecting strip **1104**, in accordance with certain embodiments. In FIG. **11**A, all four BIPV modules **1102***a*-**1102***d* are interconnected in series into a single string by interconnecting strip **1104** or, more specifically, by arranging the switches of interconnecting strip **1104** in a way to provide electrical connections to all four modules. In FIG. **11**B, switches in the interconnecting strip **1104** are arranged differently, and the four modules **1102***a*-**1102***d* form two separate strings, one including modules **1102***a* and **1102***b* and another string including modules **1102***c* and **1102***d*.

Specifically, interconnecting strip **1104** is shown to have two terminal groups (identified with dotted lines) such that each terminal group is aligned with a different row of modules. Each terminal group includes eight connector terminals. Four connector terminals in each group are configured to make electrical connections to respective contact points of the modules. These connector terminals may be referred to as external connector terminals to distinguish them from internal connector terminals that make electrical connections only to other connector terminals of the interconnecting strip and that do not make any electrical connections external to the interconnecting strip. The connection between the external connector terminals and contact points of the modules may be the same in both FIG. **11**A and FIG. **11**B configurations. Specifically, external connector terminals **1106***a* and **1106***b* are connected to top and bottom contact points of module **1102***a*, respectively. Likewise, external connector terminals **1106***c* and **1106***d* are connected to top and bottom contact points of module **1102***b*, respectively. External connector terminals **1106***e* and **1106***f* are connected to top and bottom contact points of module **1102***c*, respectively, while external connector terminals **1106***g* and **1106***h* are connected to top and bottom contact points of module **1102***d*, respectively.

Four other connector terminals in each terminal group are not directly connected to contact points of the modules and may be referred to as internal connector terminals. As explained above, the internal connector terminals make electrical connections to other connector terminals of the interconnecting strip, such as some external connector terminals and other internal connector terminals. These connections may be provided in the same terminal group and between two different terminal groups. Switches may allow changing these connections in the field as needed (for example, to move from a connection scheme illustrated in FIG. **11**A to a connection scheme illustrated in FIG. **11**B). Differences in these connection schemes will now be explained.

Starting with FIG. **11**A, internal connector terminal **1108***a* is connected to external connector terminal **1106***a*. Similar connections are provided between terminals **1108***b* and **1106***b*, between terminals **1108***c* and **1106***c*, and between terminals **1108***d* and **1106***d*. Furthermore, internal connector terminals **1108***a* and **1108***c* are also connected. Since modules **1102***a* and **1102***b* have their end connectors jumped (i.e., have contact points of the end connectors interconnected) at their other free ends, these connections form a loop between terminals **1108***a* and **1108***d* including these two modules.

A similar connection scheme is provided in the second terminal group, i.e., terminal **1108***e* is connected to terminal **1106***e*, terminal **1108***f* to terminal **1106***f*, terminal **1108***g* to terminal **1106***g*, and terminal **1108***h* to terminal **1106***h*. However, instead of interconnecting terminals **1108***e* and **1108***g*, these terminals are connected using connecting leads to terminals **1108***b* and **1108***d*, respectively. Modules **1102***c* and **1102***d* are jumped at their other ends. Furthermore, terminals **1108***f* and **1108***h* are connected to inverter connectors **1105***a* and **1105***b*, respectively. Overall, this connection scheme creates a loop of four modules **1102***a*-**1102***d* open to inverter connectors **1105***a* and **1105***b*. As described above, in different embodiments, a loop may be closed at the bottom by interconnecting terminals **1108***f* and **1108***h* and opened at any other previously connected terminals for making connection to an inverter.

Proceeding to FIG. **11**B, modules **1102***a* and **1102***b* remain interconnected according to the same scheme (i.e., connections in the first terminal group remain the same). However, connections in the second terminal group are changed to disconnect modules **1102***c* and **1102***d* from modules **1102***a* and **1102***b*. At the same time, modules **1102***c* and **1102***d* are interconnected into a separate second string, which may have its own inverter connectors **1117***a* and **1117***b*. These inverter connectors **1117***a* and **1117***b* provide separate power output that is different from output provided by inverter connectors **1115***a* and **1115***b*. In certain embodiments, these two sets of inverter connectors, i.e., inverter connectors **1115***a* and **1115***b* and inverter connectors **1117***a* and **1117***b*, may be connected to different inverters. To distinguish connections shown in FIG. **11**A from connections shown in FIG. **11**B, connector terminals of the second terminal group in FIG. **11**B are labeled with different reference numbers than in FIG. **11**A. However, one would understand that arrays **1100** and **1110** may be the same physical structure. As noted above, a change from array **1100** to array **1110** may be performed by simply adjusting one or more switches of interconnecting strip.

Specifically, FIG. **11**B illustrates terminal **1116***e* connected to terminal **1116***g*. Similarly, terminal **1116***f* is now connected to terminal **1116***h*. Module **1102***c* may remain jumped at the opposite end, while module **1102***d* is shown with two right connectors available for connecting to an inverter or other electrical components of the second string. Neither one of these four external connector terminals **1116***e*-**1116***g* is connected to any internal connector terminals **1118***e*-**1118***g*. Instead, terminals **1118***e*-**1118***g* are used for providing connections from modules **1102***a* and **1102***b* to inverter connections **1115***a* and **1115***b*. Terminals **1118***e* and **1118***g* are connected to connecting leads extending from the first terminal group. Furthermore, terminal **1118***e* is connected to terminal **1118***f*, which in turn is connected to inverter connection **1115***a*. Likewise, terminal **1118***g* is connected to terminal **1118***h*, which in turn is connected to inverter connection **1115***b*. Therefore, modules **1102***a* and **1102***b* form a first loop connected to inverter connectors **1115***a* and **1115***b*, while modules **1102***c* and **1102***d* form a second independent loop not connected to inverter connectors **1115***a* and **1115***b*.

In certain embodiments, the switching of electrical connections between various connector terminals is performed automatically. For example, a terminal group of the interconnecting strip may adjust its switches upon establishing a connection with one or more modules. This switching may be initiated when modules are being mechanically attached to (e.g., lowered onto) the interconnecting strip. A terminal group may include levers that are pushed on by a module during installation to change a position of the switch. For example, before any modules are connected to a terminal group, the terminal group may simply interconnect two sets of connecting leads attached to this group. When a module is positioned over this terminal group, a switch may be activated such that a connection between one set of these leads is broken and a connection is provided through the contact leads of this module.

In certain embodiments, an interconnecting strip is used for making electrical connections to row ends or, more specifically, to single modules positioned at the end of each row. In other words, a strip is connected only to one module in each row, instead of two. A number of connector terminals in each terminal group of such strips may be reduced by half. For example, only two connector terminals may be needed in each terminal group for making connections to contact points of the end module in that row. Additional connector terminals may be used to provide switching capabilities and/or for making connections to an inverter; however, these connector terminals are optional.

FIG. **12**A is a schematic representation of a photovoltaic string **1200** including ten BIPV modules connected by an interconnecting strip **1204**, in accordance with certain embodiments. The ten modules are arranged into five rows, with each row including two modules connected to each other and jumped at the left end. Therefore, each set of two modules represents a smaller loop with an opening on the right. The right end of each row or, more specifically, the right contact points of the right modules in each row, are connected to corresponding terminal connectors of interconnecting strip **1204**. Specifically, two contact points of module **1202***a* in the first row are connected to two respective connector terminals in the first terminal group. One connector terminal in that group is connected directly to an inverter connector **1205**_b_ by a drop line **1206** of the interconnecting strip **1204**. A drop line can also be referred to as a vertical return path. Another connector terminal is connected to a terminal in the second row to unite the loops of the first and second rows of modules and so on until the last connector terminal in the fifth row is connected to another inverter connector **1205**_a_.

In certain embodiments, an interconnecting strip is connected to modules in each row. However, other connection configurations are possible. For example, FIG. **12**B is a schematic representation of a string **1210** having two interconnecting strips **1214**_a_ and **1214**_b_ for interconnecting alternate rows, in accordance with certain embodiments. This configuration does not require any offset between two adjacent terminal groups in either one of interconnecting strips **1214**_a_ and **1214**_b_, because the strips are only connected to modules that are aligned with each other (i.e., modules in every other row). Specifically, interconnecting strip **1214**_a_ is connected to modules **1212**_a_ and **1212**_b_ in the first top row as well as to modules in the thirds and fifth rows. As shown in FIG. **12**B, all modules in these rows are aligned with respect to each other. At the same time, interconnecting strip **1214**_b_ is connected to modules **1212**_c_ and **1212**_d_ in the second row as well as to modules in the fourth row. Likewise, modules in these two rows are aligned. Therefore, the terminal groups of interconnecting strips **1214**_a_ and **1214**_b_ are not offset. However, the two strips are offset with respect to each other to accommodate an offset between adjacent rows as shown in FIG. **12**B.

In the example shown in FIG. **12**B, interconnecting strip **1214**_a_ forms a loop containing six modules and having contact points **1215**_a_ and **1215**_b_, while interconnecting strip **1214**_b_ forms a loop containing four modules and having contact points **1215**_c_ and **1215**_d_. To electrically integrate two loops into a single string, two of these contact points (e.g., points **1215**_b_ and **1215**_c_) may be interconnected and the remaining two contact points will become contact points of the integrated string.

In certain embodiments, a string of photovoltaic modules does not have continuous boundaries and may include two or more groups of modules that are physically separated from each other. The separation may be in either one of two directions (i.e., along the rows or across the rows) or both. Furthermore, two or more groups may be completely separated (i.e., modules of different groups do not touch each other as, for example, shown in FIG. **12**C) or partially separated (e.g., some modules of different groups touch each other and may be connected to each other as, for example, shown in FIG. **12**D). In partially separated examples, some rows may be disjointed and separated by other building components. At the same time, all modules in such strings can be interconnected. Interconnecting strips may be very helpful in this regard and eliminate a need for additional custom wiring of these separate groups of modules.

FIG. **12**C is a schematic representation of a string **1220** including two groups of modules **1226**_a_ and **1226**_b_ separated by a building component **1228**, in accordance with certain embodiments. For example, two groups of modules **1226**_a_ and **1226**_b_ may be installed on a rooftop and separated by a patch of asphalt shingles. Such a configuration may be used to overcome obstacles on the building structure or for other reasons. Two portions of interconnecting strip **1224** overlap with the two groups of modules **1226**_a_ and **1226**_b_ and form connections to modules in the two groups (for example, in a manner similar to the one described above with reference to FIG. **10**). Another portion of interconnecting strip **1224** extends across building component **1228** and connects the two other portions of the strip, effectively acting as an extension cord. Terminal groups of this portion may be interconnected to each other to complete the overall electrical loop and join the two smaller electrical loops (i.e., loops formed by the two groups of modules **1226**_a_ and **1226**_b_) into string **1220**. Ends of this string are represented by inverter connections **1225**_a_ and **1225**_b_. Connections to the string may also be made at any other location.

FIG. **12**D is a schematic representation of another string **1230** that has two groups of modules **1236**_a_ and **1236**_b_ separated in the horizontal direction by a building component **1238**, in accordance with certain embodiments. Connections across the rows in the left group **1236**_a_ are provided by an interconnecting strip **1234**_a_. This group forms a loop with an opening provided by contact points of module **1232**_a_. These contact points are connected to contact points of module **1232**_b_ and then to contact points of module **1232**_c_ and **1232**_d_. Module **1232**_d_ is connected to an interconnecting strip **1234**_b_, which also provides connections across the rows in the right group **1236**_b_. Therefore, modules **1232**_a_-**1232**_d_ effective integrate the groups **1236**_a_ and **1236**_b_ in the horizontal direction into string **1230**. Ends of this string are represented by inverter connections **1235**_a_ and **1235**_b_; however, any other contacts in the string may be used for this purpose.

FIG. **13**A illustrates an interconnecting strip **1300** for providing electrical connections across multiple rows of BIPV modules, in accordance with certain embodiments. Interconnecting strip **1300** includes a base sheet **1302** made from one or more insulating materials. These insulating materials may be either rigid or flexible. While rigid materials may provide some structural integrity to the interconnecting strip, flexible materials may accommodate differences in coefficients of thermal expansion and the misalignments of modules. Furthermore, flexible material may allow for forming rolls out of interconnecting strips and using these rolls during transportation and storage. This feature may help with handling particularly long interconnecting strips that may be configured to extend over a larger number of rows. Also, interconnecting strips may be integrated into a continuous roll structure from which one or more strips may be cut according to their length requirements.

Some examples of flexible materials include polyethylene, polypropylene, thermoplastic olefins, thermoplastic rubber, thermoplastic elastomer, ethylene propylene diene, monomer (EPDM), fluoroelastomers or thermoplastic vulcanizates (TPV), and flexible cast thermoset materials, such as urethanes or silicones. In general, various flexible thermoplastic elastomers that have suitable thermally durable behavior may be used. Some specific examples include SANTOPRENE® (Supplied by Exxon Mobil in Houston, Tex.), HIPEX® (Supplied by Sivaco in Santa Clara, Calif.), EFLEX® (Supplied by E-Polymers Co., Ltd. in Seoul, Korea), ENFLEX® (Supplied by Enplast Limited in Longford, Ireland), EXCELINK® (Supplied by JSR Corporation in Tokyo, Japan), SYNOPRENE® (Supplied by Synoprene Polymers Pvt. Ltd. in Mumbai, India), and Elastron® (Supplied by Elastron Kimya in Kocaeli, Turkey). Some examples of rigid materials include polyethylene terephthalate (e.g., RYNITE® available from Du Pont in Wilmington, Del.), polybutylene terephthalate (e.g., CRASTIN® also available from Du Pont), nylon in any of its engineered formulations of Nylon 6 and Nylon 66, polyphenylene sulfide (e.g., RYTON® available from Chevron Phillips in The Woodlands, Tex.), polyamide (e.g., ZYTEL® available from DuPont), polycarbonate (PC), polyester (PE), polypropylene (PP), and polyvinyl chloride (PVC) and weather able engineering thermoplastics such as polyphenylene oxide (PPO), polymethyl methacrylate, polyphenylene (PPE), styrene-acrylonitrile (SAN), polystyrene and blends based on those materials. Furthermore, weatherable thermosetting polymers, such as unsaturated polyester (UP) and epoxy, may be used. Both rigid and flexible materials described above and elsewhere in this document may include engineered polymers, which are specifically formulated to meet certain requirements specific for photovoltaic applications. For example, certain hybrid block co-polymers may be used.

Base sheet **1302** provides mechanical support to other electrical components, such as terminal groups **1308**a-**1308**d and connecting leads **1306**. Electrical components may be from one or more conductive materials, such as copper, aluminum, nickel, silicon, beryllium, tin, tellurium, silver, phosphorous, cobalt, iron, zinc, chromium, zirconium, magnesium, titanium, and combinations thereof. The flexibility of electrical components may match to that of base sheet **1302**. For example, connecting leads **1306** may be formed as stranded wires or flat strips shaped as a sinusoid or have any other suitable shaped profile, such as a series of repeated waves or other bent features.

Terminal groups **1308**a-**1308**d are used for making electrical connections to the contact points of BIPV modules and/or other electrical components of the array, such as inverters and other interconnecting strips. Each terminal group may have at least two connector terminals **1304**. A number of connector terminals in a group may depend on a number of connections to be made by this connector as described above. For example, a terminal group configured for making electrical connections to two BIPV modules may have at least four connector terminals. A terminal group configured for making electrical connections to one BIPV module or an inverter may have at least two connector terminals, as for example, inverter connection terminal group **1308**d. Additional connector terminals may be used for providing switching capabilities as described above. In certain embodiments, one end terminal group configured for making electrical connections to two BIPV modules in the end row of the string includes a jumper for interconnecting two contact points of these modules.

Two adjacent terminal groups may be separated by a predetermined distance from each other along a length of base sheet **1302**. This predetermined distance is sometimes referred to as a pitch of the interconnecting strip. In certain embodiments, an interconnecting strip is configured for connecting to every row of the string and the pitch is substantially the same as the width of the exposed portion of BIPV modules. In other embodiments, an interconnecting strip is configured for making electrical connections to every other row of the string and the pitch is about twice the width of the exposed portion.

Connecting leads **1306** extend along the length of base sheet **1302** and electrically connect the connector terminals **1304** in terminal groups **1308**a-**1308**d. Connecting leads **1306** may connect terminals in the adjacent groups as, for example, shown in FIG. **13**A and, in certain embodiments, connect terminals in end terminal groups as, for example, shown in FIG. **10**C. The later example is referred to as a drop line, drop lead or a vertical return path.

Connector terminals **1304** may include sockets extending substantially perpendicular to base sheet **1302** for connecting to contact points of BIPV modules. Connector terminals that are not connected to BIPV modules may have different designs and are generally not exposed. FIG. **13**C is a schematic expanded view of a connector terminal **1330** having a socket shape, in accordance with certain embodiments. Connector terminal **1330** includes a conductive element **1334** positioned within an insulating shell **1332**. Conductive element **1334** is configured to form an electrical connection with a corresponding BIPV module or, more specifically, with a contact point of the module. Conductive element **1334** may be made from one or more of the conductive materials listed above. Some these conductive elements may be directly connected to connecting leads, while others may be connected to internal jumpers and switches of the local terminal group.

In certain embodiments, conductive element **1334** forms a cavity for insertion of a contact point of the module. The cavity may include an insulating pin **1336** to prevent the accidental touching of conductive element **1334** prior to installation. Insulating pin **1336** may be made from the same materials as insulating shell **1332**. Some examples of such insulating materials are the materials are listed above. In certain embodiments, the base sheet, insulating shell **1332**, and insulating pin **1336** are made in a single operation, such as injection molding utilizing single stage or multiple stage injection cycles. In other embodiments, these components are made from different materials and may be mechanically interconnected by over-molding or other techniques. For example, insulating shell **1332** and insulating pin **1336** may be made from one or more of the rigid materials listed above. In the same embodiments, the base sheet may be made from one or more of the flexible materials listed above. The mechanical connection between these components that are made from different materials may be provided by over-molding one material over another material. Furthermore, electrical components insulated by these materials may provide some structural support. In specific embodiments, insulating shells **1332** and insulating pins **1336** may be formed in an initial injection molding operation, while the base sheet extending over some portions of insulating shells **1332** may be formed in a later injection molding operation. The overlap between two materials is generally referred to as overmold. In the same or other embodiments, an initial injection molding operation may be used to form mechanical supports to some electrical components, (e.g., conductive element **1334**) with respect to other elements (e.g., electrical leads) of the connector terminal. This injection molding operation usually uses special mechanical supports positioned within the molding cavity of the injection molding apparatus. These mechanical supports are then removed, and the process proceeds with another injection molding operation to form other components of the connector.

Connector terminal **1330** may include a seal **1338** extending around insulating shell **1332** and configured to seal the mechanical connection or, more specifically, any gap between connector terminal **1330** and a portion of the module used for connecting to connector terminal. The seal may be formed using an O-ring or other sealing components and material, (e.g., silicone sealant, butyl rubber inserts). In certain embodiments, a corresponding seal is provided on a module in addition to or instead of seal **1338** on connector terminal **1330**.

In certain embodiments, at least two adjacent terminal groups are offset with respect to each other in a direction along a width of base sheet **1302**. As described above, this offset may be used to accommodate an offset between adjacent rows of BIPV modules, which may be implemented for sealing and aesthetic reasons. In other embodiments, all or most terminal groups of interconnecting strip are aligned. Some terminal groups are connected directly to BIPV modules, while others are connected through an extending strip, which may be also referred to as a lateral connector. One example of such extending strip is shown in FIG. **13**B. Specifically, extending strip **1320** includes two terminal groups **1322** and **1324** and multiple connecting leads providing connections between these two groups.

FIG. **14** is a flow chart corresponding to a process **1400** for forming a photovoltaic string containing multiple rows of interconnected BIPV modules on a building structure, in accordance with certain embodiments. Process **1400** may start with installing an interconnecting strip on a building structure in operation **1402**. The interconnecting strip may be aligned such that rows of BIPV modules will extend substantially perpendicular to the strip. Furthermore, the interconnecting strip may be positioned in a location that provides an overlap with a maximum number of rows in the string. In this operation, the back sheet of the interconnecting strip may be mechanically fastened to the building structure using nails, screws, staples, or some other type of fastener. When modules are later installed over the interconnecting strip, the strip may provide additional mechanical support to the modules with respect to the building structure.

The interconnecting strip installed in operation **1402** may be configurable such that connections between its connector terminals may be adjusted to provide different connection schemes. In this situation, process **1400** may involve two optional operations to identify a connecting scheme (in operation **1404**) and to adjust switches (in operation **1406**) according to this identified scheme. Operations **1404** and **1406** may be completed before or after the interconnecting strip is installed on the building structure in operation **1402**. Furthermore, operations **1404** and **1406** may be completed for each individual row as reflected by a decision block **1410** and the loop in the flow chart.

Process **1400** then proceeds with installing BIPV modules in a row that overlaps with the interconnecting strip in operation **1408**. One of the modules in this row may form one or more electrical connections to the interconnecting strip. More specifically, electrical connections are formed between one or more connector terminals of the strip and one or more corresponding contact points of one or two modules. The one or two modules that make connections to the interconnecting strip may be electrically connected to other modules in this row, thereby forming one or more smaller electrical loops as described above.

In certain embodiments, connector terminals of the interconnecting strip extend in a direction substantially perpendicular to its base sheet such that electrical connections with one or more contact points of the BIPV module are established while lowering this module onto the strip in operation **1408**. However, other orientations of the connector terminals are possible as well. For example, a module may be slid in parallel to the interconnecting strip to establish electrical connections.

In certain embodiments, contact leads of a module may be offset with respect to connector terminals of the interconnecting strip. For example, all terminal groups of the interconnecting strip may be in line, while modules may be offset. In this situation, an extending strip may be attached between the module and interconnecting strip to provide connections between corresponding contact points and connector terminals.

If additional rows of BIPV modules need to be installed, then some operations of process **1400** may be repeated. In certain embodiments, an interconnecting strip may be extended by electrically connecting the first strip to a second strip. A combination of the two strips may allow for interconnecting more rows of BIPV modules.

Although the foregoing concepts have been described in some detail for purposes of clarity of understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims. It should be noted that there are many alternative ways of implementing the processes, systems, and apparatuses. Accordingly, the present embodiments are to be considered as illustrative and not restrictive.

What is claimed is:

1. An interconnecting strip for providing electrical connections between building integrable photovoltaic modules arranged in multiple rows, the interconnecting strip comprising:

a base sheet comprising an insulating material;

two or more terminal groups, including a first terminal group and a second terminal group, wherein each terminal group comprises at least four connector terminals; and

two or more connecting leads, including a first connecting lead and a second connecting lead, wherein:

the two or more terminal groups are affixed to the base sheet,

the first terminal group is offset from the second terminal group by a first distance,

each of the at least four connector terminals is configurable to:

electrically connect with one or more building integrable photovoltaic modules,

electrically connect with one or more of the other at least four connector terminals in the same terminal group,

electrically connect with one or more of the at least four connector terminals in a different terminal group, and

electrically disconnect from one or more of the other at least four connector terminals in the same terminal group;

each of the two or more connecting leads are configurable to electrically connect to two terminal connectors,

the first connecting lead electrically connects one of the at least four connector terminals in the first terminal group to one of the at least four connector terminals in the second terminal group, and

the second connecting lead electrically connects one of the at least four connector terminals in the first terminal group to an item selected from the group consisting of one of the at least four connectors in the second terminal group and one of the at least four connectors in another one of the two or more terminal groups.

2. The interconnecting strip of claim **1**, wherein the at least four connector terminals comprise sockets extending substantially perpendicular to the base sheet.

3. The interconnecting strip of claim **1**, wherein the first distance corresponds to a width of exposed portions of the building integrable photovoltaic modules.

4. The interconnecting strip of claim **1**, wherein two adjacent terminal groups are offset from each other by a second distance in a direction along a width of the base sheet.

5. The interconnecting strip of claim **1**, wherein:

at least one terminal group further comprises a jumper, and

the jumper electrically connects two of the at least four connector terminals of the same terminal group.

6. The interconnecting strip of claim **1**, wherein:

each of the two or more terminal group further comprises at least one jumper, and

each jumper electrically connects two of the at least four connector terminals of the same terminal group.

7. The interconnecting strip of claim **1**, wherein:

one or more terminal groups further comprise at least one integrated switches,

the at least one integrated switch is electrically connected to two or more of the at least four terminal connectors in the same terminal group, and

the at least one integrated switch is configured to change the electrical connections among the at least four connector terminals in the same terminal group.

8. The interconnecting strip of claim **1**, wherein one or more terminal groups further comprise at least six connector terminals in the one or more terminal groups.

9. The interconnecting strip of claim **1**, wherein:

one of the two or more terminal groups further comprises eight connector terminals, wherein:

two of the eight connector terminals are connected to two corresponding connector terminals in another of the two or more terminal groups; and

two other of the eight connector terminals are connected to two corresponding connector terminals in a different terminal group.

10. The interconnecting strip of claim **1**, wherein

two of the at least four connector terminals of at least one of the two or more terminal groups are movable on the base sheet.

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